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ORIGINAL ARTICLES.

I.—American Jurassic Mammals.

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(PLATES VIII. and IX.)

(*Concluded from page* 247.)

Dryolestidæ.

THE first American mammal found in the Jurassic, and a large proportion of those since discovered, belong to a peculiar family which the writer has called the *Dryolestidæ*. It includes several genera and numerous species from America, and is likewise represented among the forms found in Europe.

The type species of the group, *Dryolestes priscus*, was based upon a characteristic lower jaw, although the specimen was imperfect. A nearly complete lower jaw of the species is represented on Plate VIII. Fig. 2. An allied species, *Dryolestes vorax*, is shown on the same Plate, by Figures 3 and 4. *Stylacodon*, *Asthenodon*, and *Laodon*, other genera of this family, are likewise represented on the same Plate.

The upper jaws of several genera of this family are now known with tolerable certainty, and these will be figured and described fully in the Memoir now in preparation.

All the genera of this family have more than the typical number of teeth (44), and the general characters of the inferior dentition are well shown in Plate VIII. The lower teeth form a close-set series, without diastemas, or marked interspaces.

There are three, or four, incisors, and in those preserved, each has a distinct crown, and the series diminishes in size from in front backward. The canine is inserted by two fangs, more or less distinct, and in most forms its crown is prominent and trenchant. Three or four premolars follow, increasing in size backward, with the last usually very prominent, and in some forms larger than the canine. These premolars all have two roots, and a compressed crown. All have one main cusp, and a small posterior heel. There is usually a small anterior cusp, especially on the posterior teeth.

The molar teeth are from six to eight in number, and are essentially identical in form, and usually distinct from the premolars. The crown consists of one main external cone, high and pointed, and three internal cusps, which vary much in development in the different genera. Seen from the outside, these teeth appear to be

inserted by a single fang, but, in most cases, each has two roots, although these are nearly or quite connate. When the jaw is imbedded in the matrix, and the diminutive teeth uncovered as far as safety will permit, the features of one side only of the molars can be determined. Thus in Figure 1, Plate VIII. the outer exposed side of one lower jaw (*Stylacodon*) is shown, while in Figure 2, the inner side of another jaw (*Dryolestes*) is represented. In Figures 3 and 4, the two sides of the same jaw are placed together, and the main characters of the lower molar teeth of *Dryolestes* are thus made evident.

There are seven superior molars, and these have one main inner cone, and three outside cusps that vary in size and proportions in the different genera.

Dryolestes and Stylacodon.

The two genera most nearly allied in dentition are *Dryolestes* and *Stylacodon*, typical examples of which are shown on Plate VIII. The number of lower teeth in the best preserved specimens appears to be the same in each, while the incisors, canine, and four premolars, show no marked differences. In *Dryolestes*, the eight molars which follow are all of one type, and differ but little except in size. All have the inner middle cone of the crown as high as, or higher than the outer main cone. In *Stylacodon*, the first two of these teeth resemble the anterior premolars in shape, and like them show from the outside double fangs. The main external cone is quite as high as the opposite cusp.

In *Dryolestes*, moreover, the lower jaw is comparatively short and massive, deep below the molar teeth, with its lower margin strongly convex. The condyle in the best-preserved specimen is concave transversely, and has its lower margin nearly on a line with the summits of the molar teeth.

In *Stylacodon*, the lower jaw is long and slender, and constricted in front of the coronoid process, which slopes well upward and backward. The condyle is convex transversely, and placed considerably above the line of the teeth. The jaw is shallow below the molars, scarcely exceeding the height of the teeth themselves, while the lower border in this region is nearly straight. These differences may be readily seen in the two specimens shown on Plate VIII. Figures 1 and 2. The mylohyoid groove is well developed in both genera, and its position is essentially the same in each.

In *Dryolestes*, the mental foramen is below the first premolar. The dental foramen is beneath the front margin of the coronoid process, and at this aperture, the mylohyoid groove begins.

Asthenodon.

The genus *Asthenodon*, the type species of which is described below, agrees with the above genera in the more important characters of the lower dentition, but differs, in having the entire series of teeth much more uniform in size, and but eleven teeth behind the canine. The type of this species is the lower jaw shown in Plate

VIII. Figure 7. A second specimen referred to this species is the anterior part of another jaw, shown in Figure 6. The former jaw shows a weak canine (*a*), followed by three premolars, each with two fangs. Behind these, in place of the large, trenchant premolar seen in *Dryolestes* and *Stylacodon*, is a small tooth, which from its shape may be regarded as the first molar. The remaining teeth agree in their more important characters with the corresponding molars of *Dryolestes*. The second specimen, Figure 6, shows a similar weak canine, and in front of it, the four incisors in place, increasing rapidly in size forward, the front one being larger than the canine.

Asthenodon segnis, Marsh.

In the genus *Asthenodon*, the inferior dentition on each side is as follows:—Incisors 4; canine 1; premolars 3; molars 8.

The largest tooth in the entire lower series is the first incisor, Plate VIII. Figure 6, $_1$. The remaining incisors decrease in size backward, as shown in the same Figure, $_2$, $_3$, and $_4$. The canine (*a*) is small and weak, and its crown resembles that of the incisors. It is implanted by two roots, which are nearly connate. The three premolars behind the canine have each two fangs, and increase in size from first to last, as shown in Figure 7 of the same Plate. The following seven teeth, judging from the shape, are molars, and behind them is the alveole of one more. These molars agree in general form with those of *Dryolestes*. The form of the lower jaw also is similar in the two genera. The upper jaw of this genus is not known.

The specimens representing this species indicate an animal about the size of a Weasel. They are from the Atlantosaurus beds of Wyoming Territory.

Laodon.

A fourth genus, *Laodon*, while agreeing in the general type of lower molar teeth with the above forms, differs widely from them in other respects. The molars in this genus have the outer main cone high and pointed, as in the above genera, but the inner opposite cusp is greatly reduced in size, as shown in the type specimen represented in Plate VIII. Figure 5. There appear to have been eight molar teeth, six of which are well preserved. In front of these, are two premolars of nearly equal size, and between these and the canine, there were apparently three more, each with two fangs, making thirteen teeth in the premolar and molar series. The canine had two roots, and the last incisor was placed closely in front of it.

In this specimen the dental foramen is situated below the summit of the coronoid process. Its aperture is placed obliquely, opening backward and upward, and from its outer margin, the deep mylohyoid groove extends forward and downward, rapidly descending below the lower border of the ramus.

This lower jaw is intermediate in form between *Dryolestes* and *Stylacodon*. It has the slender straight ramus of *Stylacodon*, with

even a stronger constriction behind the molar teeth, but the jaw is deeper below the molar series, and the lower margin is convex, as in *Dryolestes*. The molar teeth resemble those of *Peraspalax*, Owen, but in that genus there is a less number of teeth, and other features, not seen in the present specimen.

The upper jaw of this genus has not yet been identified.

LAODON VENUSTUS, Marsh.

In the type specimen of this species, the inner side only of the lower jaw is shown. The alveolar border is nearly straight, while the lower margin is strongly convex. The anterior portion of the ramus is very shallow, but little, if any, deeper than the crowns of the teeth it contained. There is a well-marked mylohyoid groove, which begins at the dental foramen, and extends forward and downward, until it is lost below, directly under the second molar. The angle of the jaw extends well backward, and was not inflected, although somewhat thickened along the lower margin. The pterygoid fossa is deep and wide. The coronoid process was large, but its exact form cannot be determined.

The type specimen of the present species is from the Upper Jurassic deposits of Wyoming.

DIPLOCYNODONTIDÆ.

A third group of Jurassic Mammals is known at present from three genera, which have been found only in America. The most typical form, *Diplocynodon*, is represented on Plate IX. Figure 3, by the specimen first described. This fossil indicates one of the largest mammals yet found in the Jurassic. In this genus, there were at least three lower incisors, directed well forward. The canine is very large, elevated and trenchant, and inserted by two strong fangs. Behind this, there are twelve teeth, all essentially of the same type, so that, from the outer side alone, it is difficult, if not impossible, to distinguish the premolars from the molars. The crowns of these teeth are composed of a main external cone, with a small, elevated lobe in front, and a lower one behind. This is repeated on a reduced scale on the inner side, except that the posterior cusp is rudimentary, or wanting. The antero-posterior faces of the crowns are deeply excavated, and grooved.

The jaw is elongate, and gently curved below. The coronoid process is large and elevated. The condyle is placed very low, nearly on a line with the teeth. The angle of the jaw is produced into a distinct process (*d*), the lower margin of which bends outwards, although the process as a whole has a slight inward direction.

An upper jaw referred to this species contains the canine and eight succeeding teeth in excellent preservation. The canine is very large, and has two distinct fangs. The molar teeth have one, main, external cone, and two lateral cusps, which rise from a strong basal ridge. On the inner side, there is one main cone, with a small posterior heel. The outer face and the sides of the upper molars are deeply sculptured with irregular grooves.

The European genus *Amphitherium* may possibly belong to this family, but the lower canine has only a single root, and the molars appear quite different from those of the American forms.

Docodon.

Another genus (*Docodon*) of this family may be distinguished from *Diplocynodon* by having, in the lower jaw behind the canine, eleven teeth instead of twelve. The canine has two fangs, as in the latter genus, and the molar teeth correspond closely in form. The symphysis is very long, and the mylohyoid groove extends forward to its upper border. The type specimen of this genus is shown in Plate IX. Figure 2.

Enneodon.

A third genus, *Enneodon*, described below, is represented by two specimens, one of which is shown on Plate IX. Figure 4. The lower jaw is comparatively short and robust, and contained only nine post-canine teeth, all of the same type.

The canine in *Enneodon* is large, and, as in other genera of this family, is inserted by two well-separated fangs. Seen from the outside, its crown resembles that of a true molar, but the anterior lobe is wanting. The second premolar is larger than the first, not smaller, as in the type of *Diplocynodon*. The premolars, although of the same general form as the molars, have the surface of the crown more grooved, or striate.

A second specimen of this genus agrees with that last described in the main features of its dentition, but the lower jaw is less robust. The canine is also more slender, and there is a small diastema behind it. The first three premolars increase in size backward, but are all of similar form. The angle of the jaw is considerably below the lower margin of the ramus.

The fossils on which the two species of *Enneodon* are based were found in the Atlantosaurus beds of the Upper Jurassic, in Wyoming.

Spalacotheridæ.

The type genus of this family is *Spalacotherium* of Owen, but it is probable that he included more than one generic form under this name, in the various specimens described. In America, one well-preserved jaw has been found, which appears to indicate a distinct genus (*Menacodon*), and is described below. This specimen is represented on Plate IX. Figures 5 and 6.

In the typical specimens of *Spalacotherium*, the premolars and molar teeth are ten in number, and of the same general form. The crown consists of one, main, external cone, high and pointed, and two, short, inner cusps, nearly equal in size, in front of and behind the main cone. The canine has two fangs, and there is little or no diastema behind it.

In *Menacodon*, the molars have the same general form, but there appear to be but seven in the post-canine series. The crowns also are shorter and more robust. The canine is small, and has two roots.

MENACODON RARUS, Marsh.

In this species, the lower jaw is comparatively slender, and its inferior border is strongly convex, longitudinally. The canine was small, and directed well forward. The first three premolars are separated slightly from the canine, and from each other. The three following teeth, which may be regarded as true molars, are larger and more elevated, and behind these was the last molar, somewhat smaller in size.

In the type specimen of *Menacodon*, there is no sharply defined mylohyoid groove, but a shallow depression takes its place, as indicated in Plate IX. Figure 6.

In *Spalacotherium* there is a well-defined mylohyoid groove.

The unique specimen on which the present species is established was found in the Upper Jurassic of Wyoming.

TINODONTIDÆ.

This family is well represented by American forms, one of which, the type species of *Tinodon*, is shown on Plate IX. Figure 1. *Phascolotherium*, Owen, appears from its dentition to be an allied form, but differs in several important points, and may yet be found to represent a distinct family. The premolar and molar teeth have nearly the same form in both genera, but in *Tinodon*, there is a larger number of post-canine teeth. The coronoid process, also, is vertical, and the angle of the jaw is not inflected. The premolars have the same general shape as the molars, the crowns being composed essentially of three pointed cusps, one, main, outer cone, and two, smaller cusps, one in front and one behind, on the inner side. There is a strong cingulum on the inner surface, which may develop into an anterior lobe, or posterior heel. The mylohyoid groove is distinct. The condyle in *Tinodon* is rounded, and somewhat transverse, and is separated from the jaw by a distinct neck.

In *Tinodon bellus*, the dental foramen is large (Plate IX. Fig. 1,*f*), and looks downward and backward. It is placed somewhat behind the anterior margin of the coronoid process, and somewhat above the middle line of the ramus. The deep mylohyoid groove (*g*) leads from this opening, forward and downward.

TRICONODONTIDÆ.

Another family related to the one last described is represented by the genus *Triconodon* of Owen, and by one or two American forms. In this group, the premolars are unlike the molars. The latter are large, and their crowns are composed of three, nearly equal, trenchant cusps. The premolars are compressed and trenchant, but lack the anterior cusp. There is apparently more than one genus included under the specimens referred by Owen to *Triconodon*, but more specimens will be required to separate them.

PRIACODON.

One of the American forms, which appears to be generically distinct from the type of *Triconodon*, is represented below, on Plate IX. Figure 9, under the name *Priacondon ferox*. The type

specimen, on which it is based, was originally placed by the writer in the genus *Tinodon*, and the species named *Tinodon ferox*. This specimen is a right lower jaw, with most of the teeth in position. There are three premolars, and four molars. The premolars have one main cone, pointed and compressed, with a low cusp in front, and a larger one behind. The last premolar is large. The penultimate molar has four distinct cones instead of three. The canine was large, and directed well forward. The coronoid process is high, and inclined backward. The mylohyoid groove is nearly parallel with the lower margin of the jaw, and extends forward to the symphysis. The latter is strongly marked.

Paurodontidæ.

A peculiar genus, *Paurodon*, widely different from any form hitherto found in America, or Europe, is represented at present by a single specimen, a left lower jaw. This is shown on Plate IX. Figures 7 and 8. The entire premolar and molar series consists of only six teeth, the main features of which are seen in the figures cited. The canine is large, nearly erect, and is apparently inserted by a single fang. There is a distinct diastema between this and the first premolar. The latter is small. The lower jaw is short and massive, and there is a deep mylohyoid groove (*g*).

The molar teeth of *Paurodon* appear to agree in the general features of their crowns with those of *Achyrodon* and *Peralestes*, but the figures given by Owen of the specimens described under these names show them to be quite distinct from the present genus.

Paurodon valens, Marsh.

In this genus there were apparently two lower premolars, and four molars, all separated somewhat from each other. The premolars have a single main cusp, and a low posterior heel. Each is implanted by two roots. The molars have a single main external cone, and two low inner cusps. The mylohyoid groove extends from the pterygoid fossa to the symphyseal surface, which is large. The mental foramen is below the diastema between the canine and the first premolar.

The upper jaw of this peculiar fossil is not known.

The type specimen of this unique form is from the Upper Jurassic deposits of Wyoming Territory.

The main object of the present article is to present a typical series of the remains of known American Jurassic mammals. A discussion of the closer relations of these to the mammals from the same formation in Europe, as well as to both older and more recent forms, will be reserved for the Memoir now in course of preparation.

The vertebræ, limb bones, and other parts of the skeleton of mammals, found with the jaws and teeth here described, cannot yet be definitely associated with the latter, but an attempt to do this will be made in the Memoir.

The genera and species of American Jurassic mammals now known are given in the list below. All have been described by the

writer, in the American Journal of Science. One figure, at least, of a typical form of each new genus proposed, has also been given, either in the original description, or in the present article.

The list is as follows:—

PLAGIAULACIDÆ.

Allodon laticeps.	Amer. Journ. Sci.,	vol.	xxi.	p. 511,	1881.
,, *fortis.*	,,	,,	,,	xxxiii. p. 331,	1887.
Ctenacodon serratus.	,,	,,	,,	xviii. p. 396,	1879.
,, *nanus.*	,,	,,	,,	xxi. p. 512,	1881.
,, *potens.*	,,	,,	,,	xxxiii. p. 333,	1887.

DRYOLESTIDÆ.

Dryolestes priscus.	Amer. Journ. Sci.	vol.	xv.	p. 459,	1878.
,, *vorax.*	,,	,,	,,	xviii. p. 215,	1879.
,, *arcuatus.*	,,	,,	,,	xviii. p. 397,	1879.
,, *obtusus.*	,,	,,	,,	xx. p. 237,	1880.
,, *gracilis.*	,,	,,	,,	xxi. p. 513,	1881.
Stylacodon gracilis.	,,	,,	,,	xviii. p. 60,	1879.
,, *validus.*	,,	,,	,,	xx. p. 236,	1880.
Asthenodon segnis.	,,	,,	,,	xxxiii. p. 336,	1887.
Laodon venustus.	,,	,,	,,	xxxiii. p. 337,	1887.

DIPLOCYNODONTIDÆ.

Diplocynodon victor.	Amer. Journ. Sci.	vol.	xx.	p. 235,	1880.
Docodon striatus.	,,	,,	,,	xxi. p. 512,	1881.
Enneodon crassus.	,,	,,	,,	xxxiii. p. 339,	1887.
,, *affinis.*	,,	,,	,,	xxxiii. p. 339,	1887.

SPALACOTHERIDÆ.

Menacodon rarus.	Amer. Journ. Sci.	vol.	xxxiii.	p. 340,	1887.

TINODONTIDÆ.

Tinodon bellus.	Amer. Journ. Sci.	vol.	xviii.	p. 216,	1879.
,, *robustus.*	,,	,,	,,	xviii. p. 397,	1879.
,, *lepidus.*	,,	,,	,,	xviii. p. 398,	1879.

TRICONODONTIDÆ.

Triconodon bisulcus.	Amer. Journ. Sci.	vol.	xx.	p. 237,	1880.
Priacodon ferox.	,,	,,	,,	xxxiii. p. 341,	1887.
(*Tinodon ferox*).	,,	,,	,,	xx. p. 236,	1880.

PAURODONTIDÆ.

Paurodon valens.	Amer. Journ. Sci.	vol.	xxxiii.	p. 342,	1887.

Nearly all the mammals older than the Tertiary, judging from their dentition alone, may have lived mainly upon insects, with such accessory diet as modern Insectivores affect. The *Plagiaulacidæ*, however, show evidence of marked adaptation to some peculiar food, whether animal or vegetable cannot yet be determined with certainty. Now that the upper teeth of *Ctenacodon* are known, and trenchant teeth are found opposed to the lower cutting premolars, and tubercular molars to those below, the problem is simplified, but not solved. The evidence at present points to an animal, rather than to a vegetable, diet for all the *Allotheria*.

It is not improbable that there was a gradual change in diet in the later forms, until vegetable food predominated. The fact that the Tertiary genus *Neoplagiaulax*, Lemoine, has only a single lower

premolar coincides with this view, and if *Hypsiprymnus* is a still later descendant, the additional molars, and other herbivorous features, may be the result of this gradual change.

The few mammals known from the Trias may be placed in two families, *Dromotheridæ*, including the American specimens, and *Microlestidæ*, those of the old world. They are all quite distinct from any of the Jurassic forms, either those found in America or in Europe. Below the Trias, no Mammals have hitherto been discovered; and none are known with certainty from the Cretaceous.

Mesozoic Mammals have very generally been referred hitherto to the *Marsupialia*. An examination of the known remains of American Mesozoic Mammalia, now representing upwards of two hundred distinct individuals, has convinced the writer that they cannot be satisfactorily placed in any of the present orders. This appears to be equally true of the European forms which the writer has had the opportunity of examining. With a few exceptions, the Mesozoic Mammals best preserved are manifestly low generalized forms, without any distinctive Marsupial characters. Many of them show features that point more directly to Insectivores, and present evidence, based on specimens alone, would transfer them to the latter group, if they are to be retained in any modern order. This, however, has not yet been systematically attempted, and the known facts are against it.

In view of this uncertainty, it seems more in accordance with the present state of science, to recognize the importance of the generalized characters of these early mammals, as at least of ordinal value, rather than attempt to measure them by specialized features of modern types, with which they may have little real affinity. With the exception of a very few aberrant forms, the known Mesozoic mammals may be placed in a single order, which the writer has named *Pantotheria*.[1] Some of the more important characters of this group are as follows:—

(1.) Cerebral hemispheres smooth.
(2.) Teeth exceeding, or equalling, the normal number, 44.[2]
(3.) Canine teeth with bifid or grooved roots.[2]
(4.) Premolars and molars imperfectly differentiated.
(5.) Rami of lower jaw unankylosed at symphysis.
(6.) Mylohyoid groove on inside of lower jaw.
(7.) Angle of lower jaw without inflection.
(8.) Condyle of lower jaw near horizon of teeth.
(9.) Condyle vertical or round, not transverse.

The generalized members of this order were doubtless the forms from which the modern, specialized, Insectivores, at least, were derived.

Another order of Mesozoic mammals is evidently represented by *Allodon*, *Bolodon*, *Ctenacodon*, *Plagiaulax*, and a few other genera. These are all highly specialized, aberrant, forms, which apparently have left few, if any, descendants later than the Tertiary. This

[1] American Journal of Science, vol. xx. p. 239, 1880.
[2] The genus *Paurodon* may be an exception.

order, which the writer has termed the *Allotheria*,[1] can be distinguished from the previous group by the following characters:—

(1.) Teeth much below the normal number.
(2.) Canine teeth wanting.
(3.) Premolar and molar teeth specialized.
(4.) Mylohyoid groove wanting.
(5.) Angle of lower jaw distinctly inflected.

These characters alone do not separate the *Plagiaulacidæ* and *Microlestidæ* from some of the Marsupials, and the facts now known seem to prove that they belong to that group, where they represent, at least, a well-marked sub-order.

Of the two families of Triassic Mammals now known, the *Dromotheridæ* may be placed in the order *Pantotheria*, and the *Microlestidæ* in the *Allotheria*. According to present evidence, the former were probably placental, and the latter non-placental, and marsupial.

The modern Placental mammals were evidently not derived from Marsupials, as is generally supposed. Each group has apparently come down to the present time, by separate lines, from primitive oviparous, forms, of which the living Monotremes may be the more direct but specialized representatives. Among the diversified members of Placental mammals, the Insectivores are probably the nearest to the early type, and hence they show many features seen in the Jurassic and Triassic mammals of the order *Pantotheria*.

Among the various existing Marsupials, the Rat-Kangaroos (*Hypsiprymnidæ*) appear to be nearest to the oldest known forms represented in the order *Allotheria*, but future discoveries may, at any time, bring to light new Mesozoic mammals allied to other Marsupials.

So far as at present known, the two great groups of Placental and Non-placental mammals appear to be distinct in the oldest known form, and this makes it clear that, for the primitive generalized forms (*Hypotheria*), from which both were derived, we must look back to the Palæozoic.

EXPLANATION OF PLATES VIII. AND IX.

PLATE VIII.

FIG. 1. Left lower jaw of *Stylacodon gracilis*, Marsh; outer view.
,, 2. Left lower jaw of *Dryolestes priscus*, Marsh; inner view.
,, 3. Left lower jaw of *Dryolestes vorax*, Marsh; outer view.
,, 4. The same jaw; inner view.
,, 5. Left lower jaw of *Laodon venustus*, Marsh; inner view.
,, 6. Left lower jaw of *Asthenodon segnis*, Marsh; anterior part, outer view.
,, 7. Right lower jaw of same species; outer view.

a, canine; *b*, condyle; *c*, coronoid process; *d*, angle; *g*, mylohyoid groove; *s*, symphyseal surface.

All the Figures are three times natural size, except Figure 5, which is four times natural size.

PLATE IX.

FIG. 1. Right lower jaw of *Tinodon bellus*, Marsh; inner view.
,, 2. Right lower jaw of *Docodon striatus*, Marsh; inner view.
,, 3. Right lower jaw of *Diphocynodon victor*, Marsh; outer view.

[1] American Journal of Science, vol. xx. p. 239, 1880.

FIG. 4. Right lower jaw of *Enneodon crassus*, Marsh; outer view.
,, 5. Left lower jaw of *Menacodon rarus*, Marsh; outer view.
,, 6. The same jaw; inner view.
,, 7. Left lower jaw of *Paurodon valens*, Marsh; outer view.
,, 8. The same jaw; inner view.
,, 9. Right lower jaw of *Priacodon ferox*, Marsh; inner view.

a, canine; *b*, condyle; *c*, coronoid process; *d*, angle; *f*, dental foramen; *g*, mylohyoid groove; *s*, symphyseal surface.
Figures 2 and 3 are twice natural size, and the others three times natural size.

YALE COLLEGE, NEW HAVEN, March 26, 1887.

II.—THE RHYOLITES OF WUENHEIM, VOSGES.

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IN a paper recently read before the Geological Society,[1] I ventured the conclusion that the bulk at least of the "pyromerides" of the Continent would be found to be altered lavas of an originally glassy character. The careful drawings and descriptions of various petrographers formed a strong chain of evidence; and the observations of Mr. T. Davies[2] on materials from Bouley Bay, Jersey, seemed to establish beyond a doubt the connection between rocks authoritatively styled pyromerides and those regarded in this country as ancient rhyolites. Last autumn I visited one of the most typical continental localities, the richly-wooded Tiefenbach valley west of Wuenheim in the Vosges, and a few notes on specimens then collected may possibly be of interest to workers in a similar field.

It is at once apparent in the steep cliff-like exposure, with old slaty and sandy rocks towards its base, situated just beyond the junction of the roads from Wuenheim and Sulz, that one is dealing, not with a massive "porphyry," but with materials as diverse as those of the famous quarry near the Wrekin. Thus one rock is distinctly banded in tints of grey and yellow-brown, and proves under the microscope to be a devitrified perlite, an old obsidian rather than a stony rhyolite; while the "globular" types, made famous, since their discovery by M. Koechlin-Schlumberger, through the detailed investigations of Delesse,[3] occur in considerable variety, as may be seen even in the metal of the neighbouring roads. In some instances the spherulites, 5 millimetres to 1 centimetre in diameter, are purple-red in a yellowish matrix; in other cases they have a grey and flinty aspect. Many have become chalcedonic in the centre, and may have passed through a hollow stage before this final alteration. Radial structure is visible in the spherulites to the naked eye, and the surrounding material is evidently perlitic.

So much did the spherules at the time of their origin partake of the character of the matrix from which they were derived, that the larger lines of perlitic jointing pass frequently from one into the

[1] Quart. Journ. Geol. Soc. vol. xlii. p. 188.
[2] Min. Mag. vol. iii. p. 118.
[3] Mémoires de la Soc. géol. de France, 2me série, tome iv. p. 308, etc.

other, and aid doubtless in bringing about the alteration of the spherulites. It is to this admixture of glass and this slight differentiation from it that I would prefer to ascribe the absence of double refraction in so many incipient spherulites of modern date, rather than adopt the view held by some petrographers that such bodies may largely consist of opal.

Delesse, with his usual perception, detected in the matrix of the rock of Wuenheim the perlitic jointing, the "structure fendillée et globuleuse entrelacée," explaining it as a product of contraction when the mass had become practically solid. Microscopic sections would have revealed it to him in exceptional completeness, and the former glassy condition of these dull felsitic rocks may be considered as proved by the presence of the structure in such perfection. The spherulites, whether grey or red, are alike brown in section, and resemble the well-known type, the "felsospherites" of German authors; while their minute globulitic constitution seems to be still retained, despite the secondary granulation visible under polarised

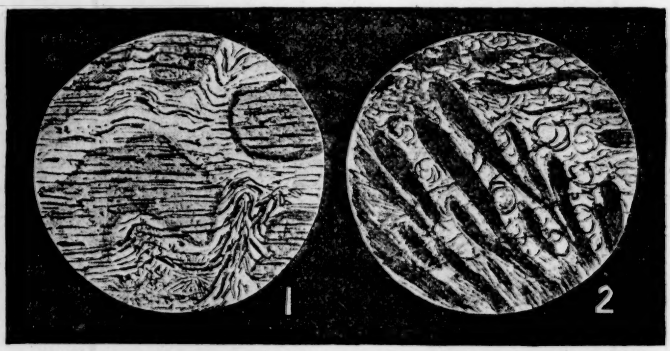


Fig. 1.—Section of rock of Tolcsva, showing disturbance of the lines of flow between the components of the large irregular spherulites. × 80.

Fig. 2.—Section of altered perlitic lava of Wuenheim, showing rays belonging to two large "skeleton-spherulites." × 18.

light. Vogelsang,[1] indeed, comments on the "surprising resemblance" between the structures of the rock of Wuenheim and certain Hungarian lavas; and it is interesting to note that Faujas de St.-Fond [2] described, eighty years ago, the similar pyromeride of Corsica under the name of *Roche porphyroïde* rather than *porphyre*, stating his belief that the constituents had consolidated more rapidly than is the case in the latter class of rocks.

The most remarkable rock from the "globular" series of Wuenheim is one of limited occurrence, in which the spherulites, about 1 centimetre in diameter, are closely crowded together, apparently to the almost complete exclusion of the matrix. Instead of being compact and homogeneous, these spherulites are seen on broken surfaces to be composed of alternating red and lighter rays, suggesting the

[1] Die Krystalliten, p. 168.

[2] Essai de Géologie, tome ii. p. 245.

presence of a coarse granophyric structure. Under the microscope, however, while the red rays resemble in constitution the ordinary spherules, the intervening matter proves to represent the matrix, now petrosiliceous, it is true, but retaining the characteristic perlitic curves, marked out often by ferruginous stains and granular products of alteration. The spherulites are, in fact, imperfect, being constructed of radially-grouped rods, circular in cross-section, stretching outwards from a more compact and normal centre. That the alternating and more transparent layers consist, not of original quartz, nor chalcedony, but of a devitrified glassy matrix, the specimen figured leaves, I think, no room for doubt. (Fig. 2.)

Further alteration might convert this material into the semblance of chalcedonic veinules, or might even replace it by bands of secondary quartz. The frequent mention by older writers—Monteiro,[1] for example—of interlamination of "quartz and felspar" in the nodules of pyromerides makes one certainly prepared for the development of granophyric structure in such masses on a handsome scale. Delesse[2] even held that the "quartz" in the rock of Wuenheim exerted some influence on the globular forms of the spherules at the time of their development, and that the alternating bands were due to a primary separation of the constituents. But in another place[3] he shows that the more siliceous fibres are probably chalcedonic, since the etching of polished surfaces of the rock with hydrofluoric acid destroys them more rapidly than the felspathic rays. M. Michel Lévy,[4] accepting the siliceous rays and veinules in the pyromeride of Gargalong as consisting of chalcedony, believes them to be primary, and to characterise a distinct type of rock, peculiar to Permian and Triassic days; that is, a rock intermediate in structure between the micropegmatites with their radial quartz and the modern lavas with spherules largely made of opal.

The example from Wuenheim, however, recalls forcibly a structure occurring in glassy rocks of comparatively recent date. Von Richthofen[5] noted in the perlites of Tolcsva and Erdobenye in Hungary certain groups, one or two inches across, of radially divergent rays, interpenetrated by the homogeneous magma, and regarded them as coarse spherulites extended outwards in this open fibrous manner until they were checked by coming into contact. Vogelsang,[6] seeking for an explanation of this abnormal mode of growth, observed that the general direction of flow of the rock, as indicated by the lines of trichites, was the same in the spherulitic rays as in the matrix, but that local disturbances in this arrangement occurred in the glassy interspaces, where the trichites seemed even to follow the outlines of the several rays. He was thus led to the conclusion

[1] Journal des Mines, tome xxxv. (1814), pp. 347 and 407.
[2] Bull. de la Soc. géol. de France, tome ix. p. 177.
[3] Mém. de la Soc. géol. de Fr. 2me série, tome iv. p. 313.
[4] Bull. de la Soc. géol. de Fr. 3me série, tome iii. (1875), p. 226. *Cf.* Noury. "Géologie de Jersey," p. 33.
[5] Jahrbuch der k.k. geol. Reichsanstalt, vol. ix. (1860), p. 180.
[6] Die Krystalliten, p. 148; also plate xvi. fig. 1.

that the spherules had originally been formed as compact and normal aggregations, but that the rock had undergone a second fusion; the glass had then penetrated the spherulites along their lines of radial structure, corroding but not destroying them, nor yet disturbing, by shifting of their parts, the parallelism of the earliest-formed crystallites within. Each spherule became thus split up into a bundle of diverging and rounded rays; and Vogelsang remarks in a later passage[1] on the similarity between this structure and that of certain felsospherites in the "kugelporphyr" of the Vosges, in which the place of the glass, however, is taken by a granular siliceous aggregate affecting polarised light.

That Vogelsang's explanation will not satisfy certain cases, while it may probably in others be regarded more as an ingenious than an inevitable deduction, is clear from sections of Hungarian "strahlige sphaerolithe" in the collection of the Normal School of Science and Royal School of Mines. In the instance figured (Fig. 1), the fluidal structure of the obsidian passes continuously through the matrix and the spherulitic matter, and is merely disturbed, not broken, in the interspaces between the rays. While this continuity excludes the idea of a second fusion, the local disturbances must have arisen from the opposition offered by the rays themselves. In a glassy lava moving with some rapidity, large spherulites are impossible, the separated globulitic materials being carried out into parallel bands. As the movement becomes slower, however, and as consolidation proceeds, nodular aggregations appear locally along this banding, and, if the crystallisation is finally arrested at this stage, their outer margins are seen to be ill-defined and ragged, set with, in fact, irregular but fairly radial rays.[2] It is conceivable that as we frequently meet in rocks with the mere skeletons of crystals planned on a scale too ambitious for the time occupied in the consolidation of the mass, so even *skeleton-spherulites* may arise, the whole product being similar in structure to the arrested external layers of the instances above described. The diverging rays, set at all angles to the direction of flow, will gradually interfere, after the manner of embedded crystals, with the further uniform progress of the glass; and the last movements in the mass, together with the pressure of upper layers, will serve to distort the lines of crystallites between the rays, or even to break them through and rearrange the particles into local lines of flow.

In some of the Hungarian cases examined, the interstitial matrix has itself become finally spherulitic, but on a minute and delicate scale, showing a mosaic of dark-cross areas when viewed between crossed Nicols. In the rock of Wuenheim, however, it seems for the most part to have remained glassy until the period of its secondary alteration into granules. The individualised fibrous structure of the spherulitic rays, which are well compared to axiolites by Rosenbusch,[3] would in itself assign to them an origin independent of one another in all but the tendency to develope in groups about

[1] *Ibid.* p. 168 [2] See Quart. Journ. Geol. Soc. vol. xli. plate iv. fig. 1.
[3] Mikroskop. Physiogr. 2nd edit. (1886), p. 395.

certain centres. The second, third, or fourth series of spikelets attaching themselves to one of the rays of a skeleton-crystal of magnetite may be considered as independent of the similar additions, whether simultaneous or not, made during consolidation to the other primary arms. One arm, moreover, in such examples frequently attains to a much greater development than the rest, and corresponding phenomena may be expected among skeleton spherulites.

I would submit these few observations as further evidence in favour of regarding the pyromerides as the altered representatives of the rhyolites of to-day, of which they reproduce, not only the familiar, but also some of the rarer types. It is interesting to observe that, equally with those of Jersey, the Wuenheim lavas are held to be of Permian age.

In the microscopic work relating to this subject, I have been much indebted to preparations made in the Geological Laboratory of the Normal School of Science and Royal School of Mines.

III.—On Some Remains of Siluroid Fishes from British Eocene Formations.

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

Among the early Tertiary Fishes in the British Museum, there are a number of detached spines and cranial fragments from the Middle and Upper Eocene beds of Bracklesham and Barton, which are undoubtedly referable to extinct members of the family of Siluridæ. With the exception, however, of three specimens figured and briefly noticed by Dixon in his work on the fossils of Sussex,[1] all have remained hitherto undescribed; nor is it an easy task to base any satisfactory identifications upon such fragmentary materials. But as it has sometimes been asserted that no traces of this family have yet been discovered in European formations,—and, as moreover, at least one important generalization has been based upon the supposed fact,[2]—it will perhaps be of interest to offer a few notes upon these fossils, to show that their non-recognition is due rather to the imperfection of the geological record, than to their actual absence in the rocks. And some slight notice is all the more desirable, since Dixon's reference of the Bracklesham specimens to the temperate genus *Silurus* is obviously erroneous, and the mistake has escaped correction in the second and revised edition of his great work.

It is impossible, of course, to attempt any precise specific diagnoses equivalent to those recognized by the zoologist among living forms; for no evidence is yet forthcoming as to the arrangement and proportions of the fins, which constitute so prominent a character of note in systematic works. But there is very good reason to believe

[1] F. Dixon, "Geology and Fossils of Sussex," 1st edit. 1850, p. 204, pl. xi. figs. 11–12 [2nd ed. p. 244, pl. 11, figs. 11–13.]

[2] "The Siluroids . . . . came into existence after the Cyprinoids, fossil remains being known only from Tertiary deposits in India, none from Europe." (A. Günther, "Study of Fishes," 1880, p. 216.)

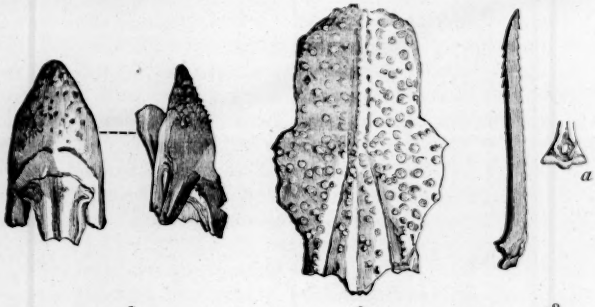
that the fossils indicate two distinct types, and it therefore seems advisable to adopt the usual palæontological expedient of applying a provisional name to each, merely for convenience of reference; and in the first case, at least, there can be little doubt that the present determination will prove well founded.

ARIUS EGERTONI, Dixon sp.

1850. *Silurus Egertoni*, F. Dixon, Geol. and Foss. Sussex, p. 204, pl. xi. figs. 11-13.

Pectoral Arch and Spine.—The finest specimen figured by Dixon among the types of this species is a right pectoral spine in natural association with the clavicular element of the supporting arch (Brit. Mus. No. 25612). A triangular dermal plate, ornamented with irregularly-disposed, large conical tubercles, is firmly merged with the clavicle in its middle portion, and extends backwards for a distance equalling half the length of the spine; and the bone is evidently preserved as far upwards as its sutural connection with the supra-clavicle, though unfortunately mutilated near the rigid lower symphysis.

Of the spine itself, the National Collection comprises several examples, which render it possible to define its characters completely. These specimens vary considerably in size, though agreeing in every other respect, and the beautiful fossil already mentioned is much the largest, while one of the smaller ones (B. M. 25736) was originally selected to show the form of the proximal articulation. All are of the ordinary laterally-compressed shape, and, when well preserved, exhibit an ornament of closely-approximated, short irregular ridges, rising at intervals into small conical bosses. In the distal half of the spine, the denticles upon the edges are large and recurved, but more proximally they become much smaller, and the points incline in the opposite direction.



1 2 3

FIGS. 1 and 2. *Arius Egertoni*, Dixon sp., M. Eocene, Bracklesham Bay, Sussex, etc.
FIG. 3. *Arius ? Bartonensis*, sp. nov., U. Eocene, Barton Cliff, Hampshire, etc.
a, median view of proximal articular end of Fig. 3.

Dorsal Spine, etc.—The dorsal spine, associated by Dixon with "*Silurus Egertoni*," corresponds so closely in the character of its ornamentation with the pectoral appendage already referred to, that there can be little doubt as to the correctness of the correlation.

But the British Museum does not appear to possess any example sufficiently large to have pertained to a fish of the dimensions indicated by the pectoral arch No. 25612; and the fossil figured by Dixon (No. 25735*a*) is one of the finest and best preserved. The spine is remarkably straight, neither the anterior nor the posterior border exhibiting more than the slightest curvature, and the distal tapering is but gradual. The lower end shows the usual facettes for its connection with the interspinous bones, and there is the ordinary "shackle joint." The row of denticles upon the anterior edge is prominent in unabraded specimens, and they are largest in the middle, diminishing towards either extremity; those at the base are merely minute tubercles, but those still higher are well-defined hooklets, with the points at first directed upwards and finally downwards.

The short blunt spine, with bifurcating base, situated in front of the larger weapon, and serving as a kind of "bolt" or fulcrum, has also been met with at Bracklesham, and is shown of the natural size in Fig. 1. There are likewise some fragments of the modified interspinous bones, though these exhibit no special features of interest.

Cranial Bones.—But the most satisfactory materials for discussion consist in a number of fragments of the cranium, which were long ago labelled by Sir Philip Egerton and Mr. William Davies as pertaining to the present species, though no description of them seems to have been hitherto published. These bones are ornamented externally in a very similar manner to the clavicular plate already noted, and their size is such that they may well have belonged to the fishes indicated by the detached fin-spines. The only element, however, that is capable of certain determination, is the supra-occipital bone—fortunately one of the most characteristic bones in the Siluroid skull—and of this four good examples are preserved: the finest is shown of the natural size, viewed from above, in Fig. 2. Anteriorly, there is a small median process dividing the posterior ends of the frontals; on either side, the sutural connections with the successive laterally-placed bones are more or less distinguishable, and the greatest breadth is attained between the squamosals; and posteriorly, where the lateral borders are free, the element exhibits scarcely any tapering, and has a comparatively abrupt termination. The upper surface is raised into a median longitudinal keel in the hinder half of the bone, and from the anterior extremity of this there diverge two well-marked mucus-canals, which appear to extend towards the point of junction of the frontal and postfrontal on each side. On the inferior aspect, the most noteworthy feature is the strength of the septum between the lateral muscles, below the post-cranial extension of the bone. There is no trace of a supraoccipital fontanelle.

Systematic Position.—From the foregoing facts, it is obvious, that the Siluroid species under consideration was characterized (i.) by the presence of a strong dorsal fin-spine in addition to the pectorals; (ii.) by a large, ornamented dermal plate attached to the scapular

arch; and (iii.) by the ornamentation of the upper cranial bones, which are evidently not covered with more than a very thin skin. In all these respects, the present species differs widely from the *Silurus*-type, and the first two characters alone, which were originally indicated by Dixon, are quite sufficient to exclude it from the genus just mentioned. Sir Philip Egerton, indeed, seems to have already recognized the fact, and has labelled some of his specimens as *Pimelodus*. But a careful comparison of the supraoccipital bone with the corresponding element in the large series of recent Siluroids in the British Museum can leave little doubt that the fossil really belongs to the well-known genus *Arius*, or to some closely allied form which cannot be distinguished upon present evidence. There is the most striking similarity in the few points as yet known, and it is scarcely likely that any great divergence will be noted in the other structures still to be revealed.

If such a conclusion be substantiated by future discoveries, the fact will become of considerable interest, as showing that this Siluroid fish belonged to a type now characteristic of tropical waters, instead of representing an existing form (*Silurus*) that rarely transgresses beyond the temperate zone; and this circumstance, of course, is in harmony with all the indications of the associated fauna. Nothing, however, can be said as to its having its nearest ally in the forms now inhabiting any particular region, for the living species of *Arius* have an extraordinarily wide distribution, and are scattered throughout the freshwaters and littoral areas in almost all tropical parts both of the Old World and the New.

Formation and Locality. — Middle Eocene: Bracklesham Bay, Sussex. Probably also Upper Eocene, Barton Cliff, Hampshire. [Egerton Collection, B. M. p. 1894*a*.]

ARIUS? BARTONENSIS, sp. nov.

The second species of Siluroid is indicated by some small spines from the Barton Clay of High Cliff, near Christchurch, Hampshire, but in this case it is impossible to determine the genus even approximately. It may belong to *Arius*, or may represent some other generic type; and the name by which we venture to designate it is, therefore, as provisional as those already applied to detached examples elsewhere. The *dorsal spine* has a very characteristic curvature, being gradually arched backwards for three-quarters of its length, and assuming a more upward direction in the distal fourth,—a peculiarity shown in the accompanying Fig. 3, though still more marked in two other less perfect specimens: and the largest example is almost twice the size of the one here represented. The sides are ornamented with irregular, delicate longitudinal ridges, exhibiting but the slightest traces of the thickenings or nodose expansions so conspicuous in the rugæ of *A. Egertoni*. The anterior edge is provided in its lower part with a short series of small, blunt tubercles; and towards the distal extremity, which becomes much compressed and sharp, there are little downwardly-directed denticles both in front and behind, imparting to the tip somewhat of a

"barbed-arrow" appearance. Posteriorly, the denticles are almost destroyed in the figured specimen, but another fossil shows that they are largest in the middle, decreasing towards either end, and the points are all inclined downwards.

The only *pectoral spines* that can be associated with this species are, unfortunately, too imperfect for description. They seem to have been considerably arched, and have an ornamentation similar to that of the dorsals.

Formation and Locality.—Upper Eocene: Barton Cliff and High Cliff, Hampshire.

Such, unfortunately, is the most complete evidence of early Tertiary Siluroids that appears to have been hitherto discovered in the European area. Among Continental works, I have only succeeded in meeting with the single description of a dorsal fin-ray ("second") and a fragment of a pectoral spine, from the Eocene (?) Beds of Austria,[1] in addition to a brief notice of the presence of the family in the Belgian Eocenes.[2] And from rocks of still earlier date, only one fish seems to have yet been referred to the same systematic position—the *Telepholis acrocephalus* of von der Marck, from the Upper Cretaceous of Westphalia;[3] and this determination, it must be admitted, is scarcely placed beyond all doubt.

IV.—Note on the Hordwell and other Crocodilians.

By R. Lydekker, B.A., F.G.S.

THE two admirable summaries of our knowledge of fossil Crocodilia recently published by Mr. A. Smith Woodward—the one relating to British forms, in this Magazine,[4] and the other, comprising the whole order, in the "Proceedings of the Geologists' Association"[5]—render it a comparatively easy matter to find out what is known concerning any particular species or genus; and I may accordingly at once proceed to the proper subject of this paper.

Hordwell Crocodiles.—In the above memoirs Mr. Woodward[6] follows the original suggestion of Sir R. Owen—more fully confirmed by Prof. Huxley—that the Crocodilian remains from the Upper Eocene (Lower Oligocene) of Hordwell described under the names of *Alligator Hantoniensis* and *Crocodilus Hastingsiæ* belong to one and the same species. The author adopts for this species the trivial name *Hastingsiæ* (although *Hantoniensis* has the priority), and retains it in the genus *Crocodilus*; remarking, however, that it presents characters which under certain circumstances might entitle it to rank as generically distinct. Sir R. Owen, in his original description of the so-called *C. Hastingsiæ*, remarked that the skull

[1] *Pimelodus Sadleri*, J. J. Heckel, "Beiträge zur Kentniss der fossilen Fische Oesterreicher," i. (1849), p. 15, pl. ii. fig. 3.

[2] H. Le Hon, "Préliminaires d'un Mémoire sur les Poissons Tertiaires de Belgique," 1871, p. 15.

[3] W. von der Marck, "Neue Fische und Krebse aus der Kreide von Westphalen," Palæontogr., vol. xv. p. 276, pl. xliii. figs. 6, 7; also *ib.* vol. xxxi. p. 248.

[4] *Supra*, Vol. II. pp. 496—510 (1885).

[5] Vol. ix. No. 5 (1886).

[6] Geol. Mag. *op. cit.* p. 509.

presented many Alligatoroid features (which are of course enhanced by the inclusion of *A. Hantoniensis* in the same species), and that it was difficult to say whether the species should really be included among the Crocodiles or the Alligators. Prof. Huxley's observations, which proved the existence of a ventral dermal armour, showed that the Hordwell Crocodilian in this respect differed decidedly from all known members of the genus *Crocodilus*; but since such an armour is present in some species of *Alligator* (including[1] *Cayman* and *Jacare*) and absent in others, this feature would not of itself necessarily exclude the species from the former genus. Professor Huxley showed, moreover, that in having the upper teeth more numerous than the lower, the species differed from *Alligator* and agreed with *Crocodilus;* while the usual presence of a notch in the skull for the reception of the fourth lower tooth is a character of the latter genus. It will suffice to mention here that the cranium is characterized by the peculiar circumstance that the premaxillæ are united superiorly, and thus separate the nasals from the anterior nares.

The reader's attention must now be directed to the genus *Diplocynodon*, which was founded by Pomel[2] upon the lower jaw of an Alligatoroid Crocodilian from the Lower Miocene (Upper Oligocene) of Allier, which presented the peculiar feature of having the third lower tooth nearly as much enlarged as the fourth—from which feature the generic name was chosen. To the type specimen Pomel applied the name *D. Rateli*, and subsequently[3] referred to the same genus the so-called *Alligator Hantoniensis*. Subsequently again H. von Meyer[4] identified with this *D. Rateli* both a Crocodilian mentioned by Bravard from Allier under the name of *Crocodilus elaverensis*, and also others from the equivalent beds of Weissenau and other places in the Mayence basin to which he had previously applied the names *C. Rathi*, *C. Bruchi*, *C. medius*, and *C. Brauniorum*. At the same time Meyer observed that this form agreed with the so-called *Crocodilus Hastingsiæ* in the peculiar relations of the pre-maxillæ and nasals; and he consequently came to the conclusion that both were very closely allied, if not specifically the same.

At a much later period M. Vaillant[5] described the Crocodilian remains from Allier and proposed for one form, in which the nasals reach the nares, the name of *Diplocynodon gracilis*; retaining that of *D. rateli* for the type mandible, which he regarded as probably distinct from his *D. gracilis*. His researches proved that *Diplocynodon* was furnished with ventral dermal armour.

In 1877 Herr Ludwig[6] described and figured the Crocodilians from the Mayence basin, and re-named the form in which the nasals did not reach the nares *Alligator Darwini* (including in that species the

[1] I follow the views of Dr. Günther in this respect.
[2] Bull. Soc. Géol. France, ser. 2, vol. iv. p. 383 (1847).
[3] Catalogue Méthodique, p. 124 (1853).
[4] Neues Jahrbuch, 1857, p 538.
[5] Ann Sci. Géol. vol. iii. art. 1 (1872).
[6] Palæontographica, suppl. vol. iii. pt. 4.

four above-mentioned names previously applied by Meyer); while to another form, in which the nasals reach the nares, he gave the name of *Crocodilus Ebertsi*. Both forms show the enlarged third lower tooth characteristic of *Diplocynodon*, and from the equivalence of the Mayence and Allier deposits and the specific identity of many of their Mammals, the *primâ facie* presumption is that they are respectively identical with the two Allier forms.

Turning once more to the Hordwell Crocodilian, an examination of the skull figured by Owen in pl. vi. of his "Crocodilia, etc., of the London Clay" (Mon. Pal. Soc.), now in the British Museum (No. 30393), shows that it has the enlargement of the third lower tooth characteristic of *Diplocynodon*; and also that the smaller upper teeth bite on the outer side of the lower ones as in the Alligators, instead of interlocking with them as in the Crocodiles; and I therefore come to the conclusion that Pomel's reference of this species to *Diplocynodon* is correct, and consequently that it should be known as *D. Hantoniensis*. I should observe, moreover, that I think there is no doubt but that *Diplocynodon* is a valid genus, presenting the peculiar feature of the enlargement of the third lower tooth, but otherwise intermediate between *Alligator* and that group of *Crocodilus* comprising the existing Indian *C. palustris* and the fossil *C. Sivalensis*. As I shall allude more fully on a subsequent occasion to the distinctive features of the genus, I will only observe here that if it be not adopted it would be necessary to include both it and *Alligator* in *Crocodilus*.

With regard to the so-called *Alligator Darwini*, I cannot observe from the characters of the figured imperfect skulls any characters by which it can be distinguished from *D. Hantoniensis*; but since it occurs on a higher horizon it may be entitled to specific distinction, and I therefore propose that it should be provisionally known as *D. Darwini*; the specific name being adopted in preference to either of the four proposed by Von Meyer, which were never properly described or figured. With this form *D. Rateli*, Pomel, is probably also identical, but the unsatisfactory character afforded by the type renders it inadvisable to adopt this name. With regard to the so-called *Crocodilus Ebertsi* the figured cranium appears to me to show no characters by which it can be specifically distinguished from the younger type cranium of *D. gracilis* from Allier; the difference in the contour of the two being apparently merely due to the different ages of the two specimens.

It will be apparent from the above that all the so-called fossil Alligators of the Old World really belong to the genus *Diplocynodon*; and since the Crocodiles (*C. palustris* and *C. Sivalensis*) which approach nearest to this genus in the structure of the cranium and form of the maxillo-premaxillary suture on the palate are confined to India,[1] it becomes an interesting question to know whether the existing Alligator recently described from China may not show signs of affinity with *Diplocynodon*.

[1] See Lydekker, "Palæontologia Indica" (Mem. Geol. Surv. Ind.), ser. 10, vol. iii. p. 216 (1886).

London Clay Crocodilians.—Having concluded what I have to say in regard to *Diplocynodon*, I may mention that a comparison of the type skulls of the so-called *Crocodilus champsoides* and *C. toliapicus*, Owen, from the London Clay, has convinced me that these forms are nothing more than young and old individuals of a single species,[1] for which we should therefore adopt the original name *C. Spenceri*, Buckland.[2] The so-called *C. Arduini*, Zigno,[3] from the Nummulitics of Verona, appears to be specifically indistinguishable from the English form.

The Wealden genus Hylæochampsa.—In his sixth supplement to the Reptilia of the Wealden and Purbeck (Mon. Pal. Soc. 1873), p. 1, Prof. Sir R. Owen applied the name of *Hylæochampsa* to the imperfect posterior part of the cranium of a small Crocodilian from the Wealden of Brook, which was figured in pl. v. figs. 23–25 of the preceding supplement of the same monograph. This specimen is new in the British Museum (No. R. 177), and differs from all other English Wealden Crocodilians by the extremely backward position of the posterior nares, which are situated immediately in advance of the pterygoids; and by the supratemporal fossæ being decidedly inferior in size to the orbits. It is further characterized by the orbits communicating freely with the lateral temporal fossæ[4] as in recent Crocodilia, instead of being completely shut off from them as in the *Teleosauridæ*. Now the above features being those given by M. Dollo[5] as characteristic of his so-called *Bernissartia*,[6] the type of the family *Bernissartiidæ*, from the Wealden of Belgium, it becomes necessary to consider in what respects that form differs from *Hylæochampsa*. On page 322 of his memoir M. Dollo observes that *Bernissartia* is distinguished from "*Hylæochampsa* par l'absence de tout échancrure orbito-latéro-temporale"; but as this statement is entirely erroneous,[7] the one point of distinction which he indicates is invalid. As far, indeed, as I can see, the cranium of *Hylæochampsa* appears to agree exactly not only in form, but also in size with that of *Bernissartia*, and I accordingly regard the two as specifically identical; in which opinion I have the support of my friend Mr. G. A. Boulenger, who has been good enough to compare the type specimen with M. Dollo's description and figure.[8] Under these circumstances the name *Bernissartia Fagesi* must apparently give way to that of *Hylæochampsa Vectiana*. The perfect preservation of

[1] Analogous modifications in a still more marked degree are exhibited in the three crania of the existing long-nosed *C. intermedius* figured by Lütken in the "Vidensk. Meddell," 1884, p. 61, pl. v.

[2] Woodward, Geol. Mag. *op. cit.* p. 508.

[3] Mem. Ac. R. Lincei, ser. 3, vol. v. p. 67, pl. i. (1880).

[4] The "échancrure orbito-latéro-temporale" of Dollo.

[5] Bull. R. Hist. Nat. Belg. vol. ii. p. 334, pl. xii. (1883).

[6] *Ibid.* p. 222.

[7] M. Dollo's statement was probably derived from Sir R. Owen's figures, but fig. 24 shows most clearly the vertical bar occurring in the middle of this vacuity; the rims of the parieto-frontal and quadrato-jugal regions having been broken away.

[8] The *onus* of proving any distinction between *Hylæochampsa* and *Bernissartia* now rests entirely with M. Dollo.

the Belgian specimens renders our knowledge of the affinities and structure of *Hylæochampsa* almost as well known as that of recent Crocodilians; and this we owe to M. Dollo's careful description.

The hinder portion of a Crocodilian skull with attached cervical vertebræ and dorsal scutes from the Wealden of Brook, preserved in the British Museum (No. 28966), appears to indicate a genus hitherto unknown in Britain. The vertebræ are amphicœlous, the scutes apparently without a peg-and-socket articulation, the orbits communicating with the lateral temporal fossæ, the posterior nares placed as in *Goniopholis*, the orbits only slightly smaller than the supratemporal fossæ, and the few remaining teeth small and slender. The whole contour of the skull is essentially Garial-like, and I have little doubt that it was produced into a rostrum. As far as I can see, it apparently agrees precisely with the skull figured in Dunker's "Mon. norddeutsch. Wealden," under the name of *Macrorhynchus Meyeri* (of which it is the type), although the palate of the latter is unfortunately not shown. Dr. Koken, who regards[1] *Macrorhynchus* as identical with *Pholidosaurus*, of the German Wealden, has, however, been good enough to send me a sketch of the palate of *Pholidosaurus Schaumburgensis*, which shows that the English specimen is generically identical with that form. The generic term *Macrorhynchus*, Dunker, which dates from 1844, is of later date than *Pholidosaurus*, and as it is preoccupied by Lacépede (1880) for a genus of Pisces, it cannot stand. Under these circumstances I propose to provisionally refer the English specimen to the second German species, which should be known as *Pholidosaurus Meyeri* (Dunker). This genus appears to bear the same relation to the existing Garials as is presented by *Goniopholis* to the Crocodiles and thus connects the former group with the typical *Teleosauridæ*; and I propose to include in the family *Goniopholididæ* all the Amphicœlian forms (*e.g. Hylæochampsa, Theriosuchus, Goniopholis, Petrosuchus*, and *Pholidosaurus*) in which the orbit communicates with the lateral temporal fossa; such family being divided into groups according to the position of the posterior nares, the form of the skull, and the nature of the armour; and occupying an intermediate position between the *Crocodilidæ* and the *Teleosaurid* .

Classification.—In conclusion, I may observe, that since observations made subsequently to the publication of Prof. Huxley's classic memoir on the "Evolution of the Crocodilia" have tended to approximate his suborders Eusuchia and Mesosuchia, and to accentuate the distinction of the two from the Parasuchia, it appears inadvisable to continue to divide the Crocodilia into these three groups, which are certainly not of equivalent value; and I accordingly think it would be preferable, while retaining the suborder Parasuchia for those extremely generalized Crocodilians which show many points of kinship to other orders, to unite the other two groups in a single suborder which might be termed Crocodilia Vera. For the two sub-

[1] Zeitschr. deutsch Geol. Ger. vol. xxxv. p. 824, note (1883). The suggestion here made that the vertebræ are procœlous has proved unfounded.

divisions of the latter, since it would perhaps be inadvisable to retain the names Eusuchia and Mesosuchia in a minor sense to their original usage, and as it is in many cases important to have a classification not depending solely upon cranial characters, I would adopt the earlier Owenian names to form a Procœlian and an Amphicœlian series. The former series would be characterized by the possession of procœlous vertebræ, and at least usually by the union of the pterygoids in a palatal plate below the narial canal. I add the saving clause in the last paragraph because it is highly probable that in some of the procœlous Crocodilia of the Cretaceous the pterygoids did not unite inferiorly.

The following table gives the grouping of the families under this scheme; the definition of the various groups being reserved for a future occasion.

Order Crocodilia.
- *A.* Suborder Crocodilia Vera.
  - *a.* Procœlian series.
    - *Crocodilidæ.*
  - *b.* Amphicœlian series.
    - *Goniopholididæ.*
    - *Teleosauridæ.*
- *B.* Suborder Parasuchia.
  - *Belodontidæ.*
  - *Parasuchidæ.*
  - *Stagonolepididæ.*

P.S.—Since the above was in type I have received a memoir by Dr. Koken on the Crocodilia of the German Wealden (Paläontologische Abhandlungen, vol. iii. pt. 5, 1887), in which the skull of *Pholidosaurus* (*Macrorhynchus*) is figured. In this memoir the author has proposed precisely the same classification as that given above, although he adopts one or two more families, and has not proposed a name for the first suborder.

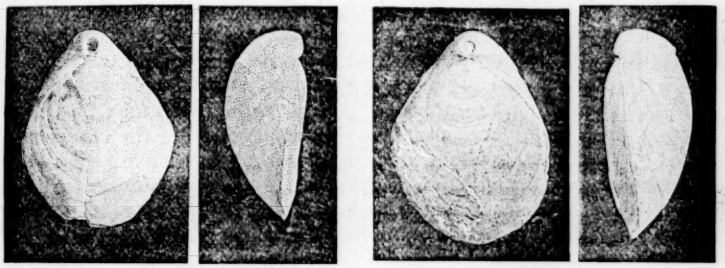
V.—On a Terebratula from the Upper Chalk of Salisbury.

By E. Westlake, F.G.S.

THE two specimens figured below are from the collection of Mr. C. J. Read, of Salisbury, who obtained them from the Upper Chalk (Senonian) of the neighbourhood. Some uncertainty has attached to the exact locality, Mr. Read having told me that he had found them in the *Mucronata*-Chalk of Clarendon; but he now writes, 18th Jan. 1887—"My belief, on thinking the matter over, is that the right locality is the 'Devizes Road,' as they were originally marked." The locality referred to is Old Camp Down lime-pit, three miles N.W. of Salisbury on the Devizes Road. This pit is characterized by an abundance of *Micraster coranguinum* and *Echinoconus conicus*; but *Terebratula semiglobosa*, Sow., usually present in this zone, does not occur, and the only Terebratulæ we have found there are the two specimens figured. As the pit is seldom worked and we have no prospect of obtaining others, it has seemed best to describe them.

Mr. Thos. Davidson, who examined them, wrote to me, 28th Feb. 1884—"These specimens are peculiar and puzzle me. They are not *T. carnea*, nor *T. semiglobosa*, and I am uncertain as to their proper identification. They approach most in shape to some specimens of *Ter. semiglobosa*, but I would not like to refer them to that species. They almost look to me a new species."

1 1*a* 2 2*a*



Terebratula obesa, Sowerby, var. *cuneata*.

Enlarged about nine-tenths natural size. The figures are photo-facsimiles. The fine surface-marking is due to the process employed (Dallastint).

Dimensions—Fig. 1. length 23·9, width 19·1, depth 10·2, foramen 1·6 mm.
Fig. 2. ,, 26·2, ,, 19·8, ,, 11·2, ,, 1·6 ,,

Shell obtusely pentagonal, elongated, depressed, slender and thin; dorsal valve nearly flat; beak projects ·8 mm. in front of the deltidium, stands off from the dorsal valve ·5 mm., and is obliquely truncated by a circular edged foramen 1·6 mm. in diameter. The pieces of the deltidium are about ·5 mm. in width. Front margin very slightly undulated.

In the British Museum are twelve specimens of "*Terebratula obesa*, Sow., from Greenhithe," (B. M. 20289) identical with the above, excepting that the dorsal valves of the B. M. specimens are rather more convex. The Chalk of Greenhithe contains *M. coranguinum* and *Echinoconus conicus*. From this zone in Hampshire I have about a thousand Terebratulæ, all of which, however, are referable to *T. semiglobosa* or *T. carnea*. I have not yet met with *T. obesa* in the Hampshire Basin.

Affinities and Differences.—Their large foramen and flattened dorsal valve include them in the *Ter. biplicata* group, which is represented in the Middle and Upper Chalk by *T. obesa*. With this species, and more especially with the large form from the Norwich Chalk, the specimens figured agree in most respects. They differ chiefly in their flatter dorsal valve and in the absence of lateral plaits, both of which may be characters of young shells. On the other hand, the same form having occurred elsewhere on the same horizon, it may be convenient to distinguish them as a variety. They differ from *T. Ciplyensis*, von Hanstein, by their thiner shell, flatter dorsal valve, more recurved beak, and smaller foramen.

REVIEWS.

I.—The Geology of England and Wales. By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales. Second Edition, pp. 670, with Geological Map and 103 Illustrations. (London: George Philip & Son, 1887.)

MORE than ten years have elapsed, as the author reminds us, since the first edition of this work was published. During the interval a considerable amount of new material had accumulated, so that the geological public were quite prepared for the revision of the original work which had been so fully appreciated that it was already well nigh out of print. A comparison of the two editions may be said to afford an outline of the progress of geology during the last decade in the Old Country, which still continues to furnish useful matter to investigators, notwithstanding the more colossal features of continental and trans-European areas, which have lately been brought to light. "The original plan of the book has not been altered, but the volume has attained a larger size, owing to the many additions necessary to do justice to the subject. Nor is this increase surprising when it is remembered that, sixty-five years ago, the excellent and in great measure original 'Outlines of the Geology of England and Wales,' by Conybeare and Phillips, filled 531 pages; and only the first part of that work was published. The aim of the present work is to afford a book of reference, useful not only to students of the scientific aspect of the subject, but also to engineers and others in its practical applications."

On the question of Nomenclature and Classification Mr. Woodward observes that, in the absence of a definite scheme formulated on the part of the International Geological Commission, the classification in the previous edition has been in the main retained. "As before, alternative groupings are stated, and, wherever possible, old and well-established names of formations are employed, while the synonyms are also mentioned. Numerous tables are given with the view of explaining more clearly the relations of the various divisions of the stratified rocks. An attempt has been made to give some historical value to the work by indicating the labours of the many geologists to whose observations our present knowledge is due." He also alludes to the assistance rendered by many of the leading geologists of the day; and expresses his indebtedness to the Councils of the Geological Society and the Geologists' Association, as also to the Editor of the Geological Magazine in the matter of reproducing illustrations. These have been further supplemented by some effective etchings by Mr. Alfred Dawson of scenery in the Isle of Purbeck, which seem to take the place of the woodcuts of the previous edition borrowed from Mackintosh's "Scenery of England and Wales." Thus we lose the illustration of the action of atmospheric disintegration afforded by the Millstone Grit of Brimham rocks (1st ed. p. 90), to have it replaced by an etching of the Agglestone near Studland, an isolated remnant of Lower Bagshot beds, locally hardened, which tells the same story (2nd ed. p. 607).

This is a book without chapters. The Introduction contains a few pages explanatory of the principles of geology, with a brief history of English geologic research. There is a very neat section across England and Wales about the parallel of Lincoln, which shows the outcrop of the Coal-measures in three distinct Coal-fields, together with their relations to the Lower Palæozoics of Wales and to the Lower Carboniferous of the Pennine anticlinal.

Part I. is devoted to the PALÆOZOIC, which is made to include the Archæan, the term now adopted instead of the Lewisian, or Laurentian, of the previous edition. So much has been done during the last ten years below the region of ascertained life that this portion of the second edition is altogether new. "The determination of the Archæan rocks in England and Wales is mainly due to the researches of Dr. H. Hicks, Prof. T. McK. Hughes, Dr. C. Callaway, and Prof. T. G. Bonney." As some portions of the evidence have been controverted by Dr. A. Geikie, the author proceeds to point out the differences of opinion which have been expressed on this most disputed subject, more especially in Pembrokeshire. "These differences in the interpretation of this ancient 'Geological Record' are serious, but perhaps not quite so serious as they at first appear. It is admitted that the rocks termed Pebidian underlie the oldest fossiliferous Cambrian strata, and rest on the rocks termed Arvonian. The relative position and origin of the Dimetian granitoid rock are the main points in question. It may be mentioned, however, that in other areas, where Archæan rocks have been identified, two main divisions are recognized, one of coarsely crystalline rocks (Dimetian), and the other of eruptive rocks (Pebidian)."

The readers of the first edition of Mr. Woodward's Geology of England and Wales will bear in mind that he fully identified himself with the Sedgwickian view of the classification of the Lower Palæozoic rocks. Hence, for him, the Cambrian system includes everything to the very top of the Bala beds. According to this arrangement his Middle Cambrian consists of the Tremadoc Slates and Lingula Flags: and further on he says, "The Middle Cambrian rocks introduce many forms of Graptolites." This is not exactly the case. The point perhaps is not one of much importance; but when we bear in mind the great change in life-forms which occurs between the Tremadoc series and the Arenig series, we must confess that the Sedgwickian is apt to minimize this biological hiatus, just as the opposite side desires to minimize the local unconformity in connection with the Llandovery series.

The correlation of the Lake-district rocks with those of Wales is very fully treated. We miss the section by Harkness at the foot of the Cross Fell range; but on the other hand there is an interesting generalized section across the Lake-district by Goodchild. Speaking generally, however, the junction line of the Skiddaws and the Volcanics should be somewhat more excavated than is there represented.

The Old Red Sandstone and Devonian, and the question of their relations to each other, are ably treated by the author, whose personal experience in surveying some of these districts lends additional

weight to his conclusions. "The relations between the Old Red Sandstone and the underlying Silurian and overlying Carboniferous rocks have been long since established. In both instances a perfect conformity exists. But only in recent years has it been fully realized that there is a great unconformity between the Upper and Lower Old Red Sandstone." In the Devonshire area there is a conformable sequence in the strata, and the Middle Devonian (marine) bridges over the interval between the Upper and Lower Old Red Sandstone in Wales, etc. In Scotland also, as pointed out by Dr. Geikie, the Old Red Sandstone must be placed in two divisions with a complete discordance between the two, the lower passing conformably into the Silurian, the Upper graduating into the Carboniferous. In the district of the Cheviot Hills, however, owing to the accumulation of volcanic material, a marked discordance is shown in Mr. Goodchild's section (fig. 16) between the "Cheviot Series" (Lower Old Red Sandstone) and the underlying Silurian, but this is evidently an exception.

When a system is thus weakened by internal discordance, whilst its extremities exhibit a disposition to amalgamate with their respective neighbours, a period of annexation seems to be at hand. At present the fossiliferous Devonian maintains a firm front against all comers, though there are not wanting geologists who would hand it over to the Silurian by way of compensation for the loss of the Ordovician rocks.

Grouping the Upper Old Red Sandstone with the Carboniferous System, the latter is held to comprise the following formations:—

Upper Carboniferous.	Coal Measures.	
	Millstone Grit.	
Lower Carboniferous.	Upper Limestone Shales and Yoredale Rocks.	Bernician and Calciferous Sandstone Series.
	Carboniferous and Mountain Limestone.	
	Lower Limestone Shales and Tuedian Beds.	
	Basement Conglomerate and Upper Old Red Sandstone.	

Nearly sixty pages are devoted to this most important system, and there are nearly a dozen sections, by way of illustration, from various authors. To begin with, there is a very effective section by J. W. Davis, showing the separation of the Yorkshire from the Lancashire Coal-fields by means of the Pennine anticlinal. The various "edges" of the Millstone Grit on the Yorkshire side are particularly well brought out. This originally appeared in the GEOL. MAG. (1878, p. 504) in a paper on the Valley of the Calder. The following sections also occur:—Draughton Quarry near Skipton (Dr. C. Ricketts), to show contortions in the Carboniferous Limestone; across the Eglwyseg Rocks, Denbighshire (Prof. A. H. Green), to show an ascending sequence; across part of Charnwood Forest (Prof. E. Hull), to show Carboniferous strata lying on the edge of the older rocks; across the Mendips (H. B. W.), to show position of the Carboniferous rocks on either side of the anticlinal; across Ingleborough (J. G. Goodchild), to show relations of the Carbon-

iferous beds to the "Cambrian" rocks, and how they are affected by the Craven faults: from Durdham Down to the City of Bristol (R. Etheridge), to show the relations of the Carboniferous Limestone, Millstone Grit and Coal-measures to the Mesozoic rocks; ideal section across the S.W. extremity of the Pendle Range (Prof. E. Hull), showing, *inter alia*, the position of the Wigan Coal-field: southern side of the South Wales Coal-field (Sir W. E. Logan): generalized section from Dartmoor to Great Haldon (H. B. W.), to show the position of the Culm Measures.

Lastly, the author devotes a few pages to the possible existence of the Coal-measures in the East and South-East of England. Figure 31 is an interesting diagram, which shows the probable curvatures of the Palæozoic beds beneath the Mesozoic rocks; but, since the undoubted discovery of the Great Oolite beneath London and Richmond, that portion of the diagram may require some reconsideration.

Amongst the economic products, he fails to give an account of the celebrated Harrogate waters, but at p. 539, under the head Mineral Springs, we find the sulphuretted springs of Harrogate duly recorded as issuing from a deep source along an anticlinal axis of the Carboniferous rocks.

Part II. Mesozoic.—The Permian rocks are grouped along with the Trias under the general title of New Red Sandstone. Doubtless there are some advantages in this arrangement, but it does seem strange to find, for instance, the Magnesian Limstone of Durham with its rich store of Palæozoic fossils being classified under this heading. That the Permian, in England, should be placed with the Secondary rather than with the Palæozoic rocks is reasonable; since there seems to have been considerable identity of physical conditions throughout the Permio-Triassic period. This indeed was one of revolution and decay, during which, but for the most part in other areas, the elements of the World's Middle Life were being slowly evolved. As a matter of fact the author's New Red Sandstone, or Poikilitic (Conybeare), to a certain extent stands alone, although biologically its lower division inclines to the Palæozoic and its Upper to the Mesozoic. The Rhætic or Penarth beds are also included here.

Mr. Woodward divides the Jurassic into Lias and Oolitic, and with the latter he includes the beds originally called by Mr. William Smith "The Sand of the Inferior Oolite." In adopting Phillips' name of "Midford Sands" for this group, we are not sure that the author is on very safe ground. What is the evidence that the Sands of Midford represent the zones of *Am. opalinus* and of *Am. Jurensis*? At this village the *Parkinsoni*-zone is seen to rest directly on certain sands of the Inferior Oolite. If the Cephalopoda-bed of the Cotteswolds occurs immediately below the junction, the name holds good; otherwise the age of the upper part of the sand is uncertain.

Nearly 100 pages are devoted to the Jurassic rocks, which have lately enjoyed a special share of the author's attention, and sections

are given by himself, Sir A. Ramsay, Messrs. Dalton, Topley, Sharp, Hudleston, Blake, Damon, Weston, and Bristow. The table on p. 286, showing the subdivisions of the Lower Oolitic rocks, may not meet the views of every geologist; but at any rate it grapples with a very difficult piece of correlation throughout this variable series in different parts of England. The Middle and Upper Oolitic beds are also very fully treated.

The Cretaceous occupy rather over 70 pages, and include sections by the author, Messrs. Topley, Bristow, Prestwich, Whitaker, Strahan, Hughes, and Dowker. The following are the divisions adopted:

Upper Cretaceous	Chalk	
	Upper Greensand	
	Gault	
Lower Cretaceous	Lower Greensand	Neocomian of some Authors
	Wealden Beds	

It is almost unnecessary to add that both as regards lithology and palæontology this system is most thoroughly dealt with; the researches of Dr. Hinde meet with frequent mention, and in addition to the names already quoted in this connection we find those of Messrs. Price, Meyer, Penning, Jukes-Browne, Barrois, and many others. As regards the Chalk itself there is a table (pp. 402, 403) showing the distribution of life zones in Yorkshire, Norfolk, Cambridgeshire, Bedfordshire, Surrey, Kent, and the Isle of Wight. The determination of these zones is due, he says, to the researches of Prof. Hébert and Mr. Caleb Evans, and particularly of Dr. C. Barrois. These have been followed out in various parts of England by several geologists. "But Mr. Whitaker has remarked that although they are very valuable when applied to particular sections, yet their application to great inland stretches of country without continuous sections, and when the structure of the deposits could be seen only in occasional pits, was by no means safe." As a surveyor, always on the look out for a feature, Mr. Whitaker prefers lithological divisions such as the Chalk Rock, the Melbourn Rock, and the Totternhoe Stone, which themselves appear to mark certain zones for a considerable distance.

Part III. Cœnozoic.—This is divided into Tertiary and Quaternary. The Tertiary rocks include all, from the Thanet Sands to the Cromer Forest Bed inclusive, and are illustrated by sections from the author and Messrs. Whitaker, Bristow, Holmes, and Prestwich. The Quaternary he divides into Pleistocene and Recent. "The Pleistocene period, so named by Lyell in 1830, includes Terrestrial, Alluvial, Estuarine, Marine, and Glacial accumulations; and the organic remains found in certain Caverns and River-deposits, being associated with relics of Palæolithic Man, these deposits are sometimes regarded as of Palæolithic age." Then follows a list of the Mammalia characteristic of the Pleistocene Beds such as *Ovibos moschatus*, *Bison priscus*, etc. The Glacial Beds are illustrated by sections from the author, Sir A. Ramsay, and Messrs. De Rance, Mellard Reade, Ussher, Searles Wood, Lamplugh, Jukes-Browne,

Clement Reid, Rev. O. Fisher, whilst illustrations of the Victoria Cave and of the Coygan Cave are borrowed from the works of Messrs. Tiddeman and Hicks respectively.

Under the head of Recent, besides the various deposits of Modern Age, he partly includes the Cave deposits, and under the subdivision Terrestrial Phenomena, refers to Springs, Swallow Holes, Tufa, Blown Sands, and Soils; and under the subdivision Marine Deposits, to Sea Beaches and Raised Beaches.

There is a supplementary section on Eruptive and Metamorphic Rocks, in which he refers to the progress in their study of late, particularly alluding to the works of Allport, Forbes, Sorby, Phillips, Rutley, Clifton Ward, Bonney, Davies, Teall, and Cole. A very useful, condensed account of these rocks has been furnished by Mr. Rutley. A "chapter" on Mineral Veins and Metalliferous Deposits, and one on Denudation and Scenery, complete the work. Appendix No. 1 records some of the more important well-sinkings and borings in England and Wales; and Appendix No. 2 gives a Synopsis of the Animal Kingdom by Mr. E. T. Newton. There is a very copious index—a matter of considerable importance in a work so comprehensive and so full of references.

A geological map 24 in. × 19·5 in. accompanies the volume. It is no longer attempted, as in the map of the previous edition, to show the East Anglian Boulder-clay and Gravels. The colours are less vivid than in the old map, and more in accordance with established usage. By colouring all the Cretaceous beds below the Gault as one, the difficulty of deciding which is Wealden and which Lower Greensand is avoided. In the same way by colouring the Trias and Permian as one, not only is the definition of their boundary avoided, but their general relations to the Carboniferous rocks of the great Pennine *massif* is made exceedingly clear and effective. We regret that the South Yorkshire Coal-field, the least exhausted in Britain, has not been differentiated from the Millstone Grit; but this is one of those accidents in printing which are apt to befall the most careful.[1] The two great volcanic areas of the Cheviot and of the Lake-district are well shown, and the chartographer judiciously colours the Archæan and Metamorphic alike. The map bears the name of Mr. Goodchild, and does him much credit.

The entire work must be regarded as a most complete compendium of English geology. The author has brought to bear upon his task an assiduity in labour and an impartiality in judgment alike remarkable. To these qualifications he adds a grasp of the subject, which years of experience in the field and in the study could alone produce. Not only is the information conveyed of the greatest utility and interest to every student of English geology, but whosoever wishes to pursue any particular subject further may obtain in this book many of the references required. Bearing in mind the enormous and varied mass of material thus sifted, it is not surprising that the publication has been a little delayed. The artist (p. 24) shows how blithely the field geologist may set

[1] We are informed that this omission has been corrected in the later-issued copies. —Edit.

about his task; but ere the consummation is reached (p. 670), ere those innumerable volumes have been consulted and annotated, the work seems to have told its tale. At the same time we hope that the author may survive to give us a third edition in due course.

W. H. H.

II.—Geologie du Département de la Sarthe. Par Albert Guillier. 4to pp. xii. and 430, with numerous Woodcuts. Published at Le Mans and Paris, 1886. Price 16 francs.

THIS monograph is published by the local authorities of the Department, and is intended as an explanation of the Geological Map of the Department, which is founded on the work of M. Triger, An Agricultural Map is also published by the same authority, and notes on the soils produced by the various rocks are given in this volume.

All this is very creditable to the local government, and one wonders if we shall ever have a similar county government in England, viz. councils by which local county affairs might be managed and from which scientific knowledge might be disseminated. During the last few years the Geological Survey has issued many descriptive memoirs, at reasonable prices, which contain much useful information, but neither the maps nor the explanations of the Survey are so well known throughout the country as they ought to be, because no steps are taken to make people in the country aware of their existence.

The Department of the Sarthe has a varied geological structure, for it possesses representatives of the following systems;—

9. Quaternary.	5. Carboniferous.
8. Eocene and Miocene.	4. Lower Devonian.
7. Upper Cretaceous.	3. Upper Silurian.
6. Jurassic.	2. Lower Silurian.

1. Cambrian (or Archæan).

Full descriptions are given of the rocks and their stratgraphical relations, with lists of the fossils found in them. There are also diagrammatic sections, but we wish that the vertical scale of these had not been so greatly exaggerated; this is a fault which the French are only slowly learning to correct.

In his first chapter M. Guillier refers to the Murchison and Sedgwick controversy, but he has hardly grasped the details of the Cambrian question, and seems to think that Murchison had independently given the name of Cambrian to rocks that were older than his Lower Silurian. He therefore applies the term Cambrian to rocks which are older than Barrande's Primordial Silurian; but these in modern nomenclature are the Pre-Cambrian or Archæan rocks. The strata actually referred to are the Phyllades de St. Lo and the Ardoises de Parennes, and it so happens that Prof. Hebert and Dr. Ch. Barrois are now at variance on the very question of whether these Phyllades should be referred to the Archæan or to the Cambrian. M. Guillier's view is that recently advocated by Prof. Hebert, though it would not appear so from his nomenclature.

Under the head of Primordial Silurian he ranges a series of schists and flaggy beds with bands of dolomite, which are stated to occur in certain localities between the Phyllades and the Grès Armoricain; but the only fossil hitherto found is a *Lingula* which Dr. Davidson identified with *L. crumena*, and this same Lingula is found in the overlying series.

The representatives of the Lower Silurian (Ordovician) are the following:—

3. White sandstones without fossils (? Grès du May).
2. Shales with *Calymene Tristani*.
1. The Armorican sandstone and red shales.

The two lower stages are probably of Arenig age, No. 2, containing also *Calymene arago*, *Asaphus nobilis*, *Illænus giganteus*, *Placoparia Tournemmei*, and *Cheirurus Guillieri*.

The beds of true Silurian age are (1) Sandstones and Carbonaceous Shales with *Graptolithus colonus*; (2) Shales with *Cardiola interrupta*. We may notice that neither here nor in treating of the other Palæozoic groups are any estimates of their thicknesses given.

Of the Devonian system only the lower portion is found, and this consists of (1) Sandstone; (2) Shales; (3) Limestone, the last being rich in fossils.

A great break then supervenes, neither Middle nor Upper Devonian nor the lowest part of the Carboniferous being represented. The Devonian Limestone is succeeded by a series of sandstones and shales which include beds of workable anthracite and a band of limestone containing *Producta gigantea*—a series which is referable to the upper part of our Carboniferous Limestone. No true Coal-measures occur nor any strata of Permian or Triassic age.

The succeeding beds are Jurassic and belong to the Middle Lias (limestone with *Pecten equivalvis*, 18 feet) and to the Upper Lias (marls and limestones with *Am. bifrons* and *Am. serpentinus*, thickness 24 feet).

The Oolitic series is well represented, as shown by the following tabular view:—

Kimeridgien.	Limestone with *Astarte minima*.
Corallien.	Sandstone with *Trigonia*. Oolitic Limestone. Ferruginous sands.
Oxfordien.	Clay and Limestone of Aubigné. Clay and Limestone of La Vacherie.
Callovien.	Ferruginous Limestone with *Am. coronatus*. Clay and Limestone with *Am. macrocephalus*.
Bathonien.	Montlivaltia Limestone. Marls with *Terebratula cardium*. Oolite of Mamers. Lithographic Limestone. Oolite with *Rhynch. spinosa*.
Bajocien.	Oolite with *Am. Parkinsoni*. Oolites with *Ter. perovalis*.

The Cretaceous rocks of Sarthe possess a peculiar interest because they include the type of D'Orbigny's Cenomanien stage; the beds composing this stage are evidently shore deposits of the Cenomanien sea and beds of sand with *Rhynchonella compressa*, *Terebratella*

Menardi, and *Ammonites navicularis* occur near the top of the division, showing that these species continued to exist along the shores throughout the Cenomanien stage. The local succession, however, is just as clear as our own, and according to M. Guillier the arenaceous beds pass laterally into the ordinary chalky facies or Normandy type, the parallelism being as follows:—

6. Marne à *Ostrea biauriculata.* } Craie à *Bel. plena.*
5. Sables à *Rhynch. compressa.* }
4. Sables et grès du Mans passing into Craie de Theligny, both with *Turrilites costatus.* }
3. Sable à *Perna lanceolata.* } Craie de Rouen.
2. Craie et argile glauconieuse à *Pecten asper.* }
1. Glauconie à *Ostrea vesiculosa* = Gaize des Ardennes.

In this he differs from Prof. Hebert, who does not admit the synchronism of the Grès du Maine and the Craie de Rouen. He also differs from the same authority in regarding the Cenomanien as succeeded conformably by the Turonien, which is divisible into three zones.

3. Craie à *Terebratella Bourgeoisii.*
2. Craie à *Inoceramus problematicus* (*mytiloides*).
1. Craie à *Terebratella Carentonensis.*

These are succeeded by Chalk with *Spondylus truncatus*, which is classed as Senonien.

At the base of the Eocene are placed certain sands and clays with flints, but English geologists would probably doubt the evidence of stratigraphical succession and the propriety of classing them as Eocene. The true Eocene strata are as follows:—

4. Clay of La Bosse.
3. Freshwater Limestone of St. Aubin.
2. Sands with Sabalites.
1. Conglomerates.

The conglomerates and sands are correlated with our Middle Bagshots and the limestone with the upper part of the Calcaire Grossier (Bracklesham).

A small area of Faluns (Miocene) comes into the Department. Lastly the so-called Quaternary deposits are described, and there are short chapters on Metamorphic and Eruptive Rocks, on Building Stones, and Mineral Waters, while a Bibliography and Index complete the volume.

We regret to find that the author died before its publication, so that the revision of the latter part was performed by one of his pupils.

III.—The Geological and Natural-History Survey of Minnesota. The Thirteenth Annual Report, for 1884, pp. 196; the Fourteenth Annual Report, for 1885, pp. 353, 8vo. (St. Paul's, 1885 and 1886.)

WITH the exception of some valuable information to farmers and others as to Insects injurious to the Cabbage, by O. W. Oestlund, some Notes on the Mammals of Big-Stone Lake, by C. L. Herrick, and a paper on Minnesota Geographical Names derived

from the Dakota Language, by Prof. A. W. Williamson, the whole of the Thirteenth Report is devoted to Geology. After a few notes on reconnoitering trips into Pope County, and to Vermilion Lake, we come to a paper on the Vermilion Iron-ores of Minnesota. Full details are given of the various mines, with a table showing that in ten years the gross product of metal has been 6,831,285 tons. Some important analyses of the hard hæmatites are given. The crystalline rocks of Minnesota, which appear to consist of gneisses and "soft red granites," are treated of at pp. 36–38. Information as to the Humboldt Salt Well in Kittson Co. is given, with details of a boring to a depth of 644 feet; "it remains for the future to determine whether these salt-deposits shall become economically of importance to the North-west." Details of other wells are given, bored apparently for fresh water, one reaching a depth of 1800 feet (p. 54), and a second 1160 feet (p. 57). The geological formations through which these two wells pass are not given, but the latter begins about 90 feet below the top of the St. Lawrence limestone. Two interesting finds are those of *Lingula Calumet* and *Paradoxides Barberi*, in the blood-red catlinite of the Great Pipestone Quarry in Pipestone Co., a rock of Huronian age (pp. 65—72). Figures of these interesting but rather obscure organisms are given in plate i. A catalogue of the specimens registered in the General Museum in 1884 occupies nine closely-printed pages and contains many interesting specimens of local and other rocks. Mr. Warren Upham (pp. 88—97) gives some notes on the geology of Minnehaha Co., Dakota, where Potsdam quartzite seems to predominate. Professor H. W. Winchell's valuable paper on "The Crystalline Rocks of the North-west" (pp. 124—140), read before the American Association in 1884, is here printed. The peat, clay, and "Cretaceous" leaves of Blue-earth Co. are noticed; and a fossil Elephant tooth, from Winona Co., is described and figured (pl. ii.) as being probably *E. primigenius*. The glacial deposits receive a due share of attention. Dr. G. M. Dawson has a paper on the microscopic structure of some Boulder-clays, and the organisms found in them (pp. 150—163). He seems to have recognized certain minute bodies as Annelid jaws, and compares them with those described by Dr. Hinde in the Silurian and Devonian Rocks of Canada. Foraminifera are also abundant, and a special paper by Messrs A. Woodward and B. W. Thomas on some specimens from the Boulder-clay of Meeker Co. is given at pp. 164—177. These fossils were found in fragments of shale derived from the Cretaceous beds of Pembina Mountain, in Manitoba, whence Dr. G. M. Dawson obtained similar specimens. Two plates are given (pl. iii. and iv.), but they are unfortunately very inferior to the plates usually seen in American Governmental Reports.

The first paper with which we are concerned in the Fourteenth Report is on some deep wells in Minnesota, by N. H. Winchell, with an appendix at p. 348. The second is by E. O. Ulrich on Lower Silurian Bryozoa (pp. 57–103), mostly obtained from the Trenton Shales. A list of 92 species is given, and of these about 50 are

described, but not figured. The Survey, however, proposes to publish a monograph of the Silurian Polyzoa before long. Mr. Ulrich also contributes a paper on Crinoidea, and describes three new genera, *Cremacrinus*, *Deltacrinus*, and *Halysiocrinus* (pp. 104–113). The list of specimens acquired by the Museum in 1885 fills ten pages, and shows, we should imagine, a very satisfactory state of things. Some new fossils are described at pp. 313–318 (pl. i. and ii.), by Prof. Winchell, one of them being a specimen of the peculiar form, *Cryptozoon*, described recently by Prof. James Hall. Mr. Winchell also writes upon a peculiar ore and the Cambrian rocks of the State of Minnesota (pp. 319–337). The most bulky contribution to this Report is "The Bibliography of the Foraminifera," by Prof. Anthony Woodward (pp. 167–312). His work having been anticipated by Mr. H. B. Brady's bibliography in the "Challenger" Report, so well known to workers on the subject, Prof. Woodward has rearranged the results of his own work with the materials of the published list, and has given it in alphabetical order in groups under countries. His work, though, as he truly says, incomplete, is useful; but unfortunately it is marred by very numerous typographical and bibliographic errors. The page and a half of *errata* for the list stop hopelessly at seventy pages from its end. Such errors as occur unnoticed in the references will prove serious hindrances to the utility of his work. Instances taken at random,—such as duplicate entries and wrong dates given with Dawson, at p. 180; with Jones at pp. 184 and 202, and with Ehrenberg at pp. 193 and 194; errors at p. 271, "Bisherigebnisseder Tiefbohrung," etc.; p. 252, Tregnem; p. 245, Milne-Ewards; p. 286, Summersetshire, etc., make the reader regret that so useful a work should have been printed without correction. *Eozoon* has a separate bibliography; and *Receptaculites* is included in the general list.

Besides a few pages of matter relating to geological and chemical research not mentioned above, there is Mr. O. W. Oestlund's "List of the Aphididæ of Minnesota, with descriptions of some new species" (pp. 17–56), unfortunately without figures; also Conchological Notes, by U. S. Grant (pp. 114–124). T. R. J.

IV.—Physical Geology of West British Garwhal, with Notes on a Route Traverse through Jaunsar Bawar, and Tiri-Garwhal. By C. S. Middlemiss, B.A. Records of the Geological Survey of India, vol. xx. Part i. 1887, pp. 26–40, with 2 maps and plates of sections.

THE second and most important part of this memoir deals with the geological structure of a tract situated 120 miles N.E. of Delhi, and bordered on the N. and S. by the Sub-Himalayan boundary and the Nyar river, and E. and W. by the Ganges at Hardwar and Ghungti mountain. It is illustrated by a small-scale map of the whole area and its N.W. corner by one on the one-inch scale. In the district are found Tertiary strata (Nummulitic and Sub-Himalayan), Mesozoic grits and impure limestones, both fossiliferous; massive unfossiliferous limestones, purple slates and volcanic breccia, and

a schistose series, all of uncertain age. Mr. Middlemiss designated the oval tract of schistose rocks running N.W. and S.E. as the *Inner Formation*, and the oval rings of the other formations which sweep round it the *Outer Formations*. He finds that the outer formations at every point dip into and under the central tract, and that the schistose rocks themselves are arranged in an elongated quaquaversal so as to complete the appearance of a synclinal whose highest rocks are the schists. That the whole area is not inverted is proved by the constant sequence of the fossiliferous horizons (Mesozoic below Nummulitic), and as these are in their proper place, the massive limestone and volcanic series are pretty certainly in their right order beneath. What then is the true place of the schists? At some spots Mesozoic beds dip directly beneath the schists, but at others the Nummulitic intervenes and is found actually in contact with schists and quartzites "without any semblance of what can be called a transition rock." "To satisfy a condition of this kind the most glaring case of selective metamorphism would be totally inadequate;" and therefore the whole set of outer formations must be younger than the inner formations. The author then urges that the constant infraposition of the outer formations must be more than a coincidence, indeed a necessary concomitant of the Post-Nummulitic mountain building of the Himalayas, in which the rocks were compelled to take up less horizontal room by sigmoidal-flexure and over-faulting;—it is the story of the Highlands told in a new country. The Scotch work of Lapworth and the Alpine work of Heim are bearing good fruit in India, and we may be sure the Himalayas will do their share in elucidating the principles of mountain structure and earth-movement.

W. W. W.

V.—The Essex Field Club.

AMONG the most enterprising of our local scientific societies is the Essex Field Club. Like the Cumberland Association, its aim is to record facts of local importance; but its publications, while illustrating the Natural History, Geology, and Pre-historic Archæology of Essex, include some essays and memoirs of much wider interest. In 1885 the first of a series of special memoirs was published, and this, the work of Prof. Meldola and Mr. William White, was a Report on the East Anglian Earthquake of April 22nd, 1884. It contains a list of British Earthquakes which have caused structural damage, and full particulars of the last important earthquake which originated beneath the surface of Essex, and was attended by so much damage to buildings. The report should be in the hands of all those interested in Earthquakes; it is a model upon which other reports might be based, and furnishes many suggestions on what to observe in connection with the catastrophes. Of great interest also is the Presidential Address delivered by Mr. T. V. Holmes at the annual meeting of the Club in 1886; it deals with British Ethnology, being a review of the evidence of characteristics and race-affinities of the various settlers in the British Islands, and the extent of their probable survival at the present day.

The Council of the Essex Field Club have resolved now to issue their "Transactions" and "Proceedings" combined in the form of a monthly periodical under the name of the "Essex Naturalist." This periodical should command an extensive circulation, for it includes many short notes of interest connected with the county, as well as papers read before the club; among the illustrations is a reproduction of Norden's Map of Essex, printed in 1594.

VI.—Transactions of the Leeds Geological Association.

THIS Geological Association, which has been established twelve years, commenced in 1885 the publication of its Transactions. The first part contained the papers read during the sessions 1883–85, and the second part (just received) contains the record of the Proceedings during 1885–86. The papers are printed only in abstract, and they include the Inaugural Address of the President, Mr. C. D. Hardcastle, on the Geology of Ingleton and the neighbourhood; an account of Recent Discoveries of Carboniferous Vegetation in Yorkshire, by the Hon. Secretary, Mr. S. A. Adamson; notes on the Drift of the North of England by Prof. Green: and various other papers. There are also reports of Field Excursions, which contain information of much local interest.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 25, 1887.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Remains of Fishes from the Keuper of Warwick and Nottingham." By E. T. Newton, Esq., F.G.S.; with Notes on their Mode of Occurrence by the Rev. P. B. Brodie, M.A., F.G.S., and E. Wilson, Esq., F.G.S.

This paper gave an account of two series of fossil fishes which have been discovered in British Triassic strata. The specimens are very fragmentary, but the rarity of Ganoid fish-remains in the English Trias lends considerable interest to these discoveries. The first series noticed were obtained by the Rev. P. Brodie in the Upper Keuper of Shrewby, and consist of some half dozen portions of fish, all small and much broken. The characters of the scales and the positions of the fins, together with as much of the form as can be made out, point to their belonging to the genus *Semionotus*. The second series were obtained by Mr. E. Wilson, F.G.S., of the Bristol Museum, from Keuper Beds near Nottingham. A large number of specimens were in this case collected; but all of them are too much broken and crushed out of shape to allow anything very definite to be said about them. Some of these also appear to be *Semionotus*; they agree in size, as well as in some other particulars, with the Shrewby fishes, and may perhaps belong to the same species; but others, on account of their strongly heterocercal tail and ornamented scales, seem to belong to the Palæoniscidæ. The presence of a third form among these Nottingham fishes is indicated by

masses of larger scales. The Rev. P. B. Brodie and Mr. Edward Wilson each appended notes on the Triassic beds from which the fishes were obtained.

2. "Considerations on the Date, Duration, and Conditions of the Glacial Period with reference to the Antiquity of Man." By Prof. Joseph Prestwich, M.A., F.R.S., F.G.S.

After showing how the discoveries in the valley of the Somme and elsewhere, 28 years ago, led geologists who had previously been disposed to restrict the age of man, to exaggerate the period during which the human race had existed, the author proceeded to discuss the views of Dr. Croll on the date of the Glacial epoch. Dr. Croll, who had at first referred this to an earlier phase of orbital eccentricity, commencing 980,000 years ago, subsequently regarded it as coinciding with a minor period of eccentricity that commenced 240,000 and terminated 80,000 years since. This last estimate was chiefly supported by the amount of denudation that had subsequently taken place.

The efficacy of the increased eccentricity of the earth's orbit in producing the cold of the Glacial epoch was shown to be very doubtful; for as similar changes in the eccentricity had occurred 165 times in the last 100 millions of years, there must have been many glacial epochs in geological times, several of them much more severe than that of the Pleistocene period. But of such glacial epochs there was no valid evidence. Another inference from Dr. Croll's theories, that each glacial epoch consisted of a succession of alternating cold and warm or interglacial phases was also questioned, such alternations as had been indicated having probably been due to changes in the distribution of land and water, not to cosmical causes. The time requisite for such interglacial periods as were supported by geological evidence was more probably hundreds than thousands of years.

Recent observations in Greenland by Professor Helland, Mr. V. Steenstrup, and Dr. Rink, had shown that the movement of ice in large quantities was much more rapid, and consequently the denudation produced much greater than was formerly supposed. The average rate of progress in several of the large iceberg-producing glacers in Greenland had been found to be 36 feet daily. Applying these data and the probable accumulation of ice due to the rainfall and condensation to the determination of the time necessary for the formation of the ice-sheet, the author was disposed to limit the duration of the Glacial epoch to from 15,000 to 20,000 years, including in this estimate the time during which the cold was diminishing, or Postglacial time.

Details were then given to show that the estimate of one foot on an average being removed from the surface by denudation in 6000 years, on which estimate was founded the hypothesis of 80,000 years having elapsed since the Glacial epoch, was insufficient, as a somewhat heavier rainfall and the disintegrating effects of frost would produce far more rapid denudation. It was incredible that man should have remained physically unchanged throughout so long a period. At the same time the evidence brought forward by Mr. Tiddeman, Dr. Hicks, and Mr. Skertchly of the occurrence of

human relics in preglacial times, had led the author to change his views as to the age of the high-level gravels in the Somme, Seine, Thames, and Avon valleys, and he was now disposed to assign these beds to the early part of the Glacial epoch, when the ice-sheet was advancing. This advance drove the men who then inhabited western Europe to localities such as those mentioned which were not covered with ice. Man must, however, have occupied the country but a short time before the land was overwhelmed by the ice-sheet. The close of the Glacial epoch, *i.e.* the final melting of the ice-sheet, might have taken place from 8000 to 10,000 years since. Neolithic man made his appearance in Europe 3000 to 4000 years B.C., but may have existed for a long time previously in the east, as in Egypt and Asia Minor civilized communities and large States flourished at an earlier date than 4000 B.C.

3. "Notes on some Carboniferous Species of *Murchisonia* in our Public Museums." By Miss Jane Donald. Communicated by J. G. Goodchild, Esq., F.G.S.

The paper gave a history of the genus *Murchisonia*, an account of the relations between it and *Pleurotomaria*, and of the resemblances to it afforded by certain recently discovered species of *Turritella*. The synonymy and a new description of the genus followed, and then of the species *M. angulata*, *M. Kendalensis*, *M. Verneuilliana*, and four forms, for which new names were proposed, were described and discussed, with notes on the localities where each had been found and the museums in which the specimens described were preserved. The new species were named :—*M. pyramidata*, *zonata*, *sphærulata*, and *tenuissima*.

II.—June 8, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read :—

1. "A Revision of the Echinoidea from the Australian Tertiaries." By Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

After calling attention to a previous paper by himself published in the Society's Journal for 1877, and to additions to the fauna made by Prof. R. Tate and Prof. M'Coy, the author proceeded to give notes on the characters, relations, and nomenclature of the following 29 species of Echinoidea :—

Cidaris (*Liocidaris Australiæ*).
Cidaris (*Liocidaris*), sp.
Goniocidaris, sp. spines.
Salenia tertiaria.
Psammechinus Woodsi.
Ortholophus lineatus.
Paradoxechinus nodus.
Clypeaster folium, var. *elongata*.
C. gippslandicus.
C. (*Monostichia*) *australis*.
C. (*Monostichia*) *Loveni*.
Echinobrissus Australiæ.
Catopygus elegans.
Pygorhynchus Vassalei.
Echinolampas ovulum.
Holaster Australiæ.
H. difficilis (*Rhynchopygus dysasteroides*).
Micraster brevistella.
Maretia anomala.
Megalaster compressus.
Pericosmus gigas.
P. Nelsoni.
P. compressus.
Lovenia Forbesi.
Euspatangus rotundus.
E. Laubei.
E. murrayensis.
E. Wrightii.
Schizaster ventricosus.

A few notes were added on the relations between this fauna and that now inhabiting the Australian seas, also on the connexions with the Tertiary Echinoidea of New Zealand, Sind, etc.

2. "On the Lower Part of the Upper Cretaceous Series in West Suffolk and Norfolk." By A. J. Jukes-Browne, Esq., B.A., F.G.S., and W. Hill, Esq., F.G.S.

The district described in this paper is that of West Suffolk and Norfolk, and is one which has never been thoroughly examined; for no one has yet attempted to trace the beds and zonal divisions which are found at Cambridge through the tract of country which lies between Newmarket and Hunstanton. Until this was done the Hunstanton section could not be correlated definitely with that of the neighbourhood of Cambridge. It was the authors' endeavour to accomplish this, and the following is an outline of the results obtained by them.

The paper was divided into six parts:—(1) Stratigraphical, (2) Palæontological, (3) Microscopical, (4) Chemical Analyses, (5) Faults and Alteration of Strike, (6) Summary and Inferences. In the first four parts separate lines of argument were followed, and each led to the same set of conclusions.

The chief interest of the paper probably centres in the Gault, and its relation to the Chalk Marl and the Red Chalk. Quite recently the very existence of Gault in Norfolk has been disputed, but the authors think the facts they adduce and the fossils they have found will decide that point. The Gault at Stoke Ferry is about 60 feet thick, and in the outlier at Muzzle Farm *Ammonites interruptus* occurs plentifully in the form of clay-casts with the inner whorls phosphatized. At Roydon a boring was made which showed the Gault to be about 20 feet thick, the lower part being a dark blue clay, above which were two bands of limestone enclosing a layer of red marl, and the upper 10 feet were soft grey marl; the limestones contained *Amm. rostratus*, *Amm. lautus*, *Inoceramus sulcatus* and *Inoc. concentricus* (?), while the marls above contained *Belemnites minimus* in abundance. At Dersingham another boring was made which proved the grey marl (2 feet) to overlie hard yellow marl, passing down into red marl which rests on Carstone. The grey marl thins out northward, and as the red marl occupies the position of the Red Chalk, the authors believe them to be on the same horizon, an inference confirmed by the presence of Gault *Ammonites* in the Red Chalk.

Another point of importance is the increasingly calcareous nature of the Gault as it is followed northward through Norfolk. This was regarded as evidence of passing away from the land supplying inorganic matter, and approaching what was then a deeper part of the sea; this inference is borne out by the microscopical evidence.

As regards the Chalk Marl, it also becomes more calcareous: at Stoke it is still over 70 feet thick, and its base is a glauconitic marl which can be traced to Shouldham and Marham, but beyond this the base is a hard chalk or limestone, which is conspicuous near Grimston and Roydon, and passes, as the authors believe, into the so-called "sponge bed" at Hunstanton.

The Totternhoe Stone is traced through Norfolk, but is thin at Hunstanton (2 feet); its existence, however, enables the limits of the Chalk Marl to be defined, with the result that some 13 feet of the hard Chalk at Hunstanton must be referred to that subdivision.

The Grey Chalk also thins northward, and from 90 feet near Cambridge, is reduced to about 30 at Hunstanton. The Belemnite-marls are traceable in Norfolk, but either thin out or are replaced by hard white chalk near Heacham.

The Melbourn Rock is continuous, and maintains similar characters throughout.

The total diminution in the thickness of Lower Chalk is from 170 feet at Newmarket to 55 feet at Hunstanton, viz. 115 feet. An endeavour was made to estimate the amount and extent of Gault removed by erosion from Arlesey and Stoke Ferry.

3. "On some Occurrences of Piedmontite-schist in Japan." By B. Kotô, Esq. Communicated by Frank Rutley, Esq., F.G.S.

The occurrence of mangan-epidote or piedmontite in connexion with the glaucophane-bearing rocks, in the crystalline schists of Japan, had already been indicated by the author. But the "*murasaki*" or violet-rock contains it as an essential component. This is well developed near Tokusima, and its geological range has been traced further. The piedmontite occurs in this rock along with fine quartz-grains under a schistose arrangement, the accessories being muscovite, greenish-yellow garnet, rutile, some felspars, iron-glance, etc.

The crystals of piedmontite are elongated, cracked, and much striated, and occur with the orthopinacoid parallel to the planes of schistosity. The crystal faces are, as a rule, well developed, thus differing from common epidote, regarded as a rock-forming mineral. Twinning is rare; cleavages upon the base and orthopinacoid are sometimes observed. The clino-pinacoidal sections of the mineral show the most intense colours; the polarization-colours are magnificent. The following is the analysis:—

SiO_2	36·16
Al_2O_3	22·52
Fe_2O_3	9·33
Mn_2O_3	6·43
CaO	22·05
MgO K_2O, Na_2O	0·84
H_2O	3·20
	100·53

The chemist expresses a doubt as to whether the iron exists in the state of sesquioxide or monoxide. The author then alludes to the difference of opinion as to the state of oxidation of iron in the Swedish and Alpine piedmontites, and suggested that the Japanese mineral supplies a missing link between the two. The Japanese mineral was originally mistaken for tourmaline, and the rock called Tourmaline-schist by E. Naumann. Although comparatively rare both in Piedmont and Sweden, in certain parts of Japan it is so

abundant as to constitute a rock-forming mineral, whilst as an accessory it occurs also in the glaucophane-schist.

The author further describes a peculiar epidote, containing iron, from the glaucophane-schist, and also a peculiar garnet, occurring in rhombic dodecahedra about the size of a pea, which includes many other minerals, but no glaucophane. The garnet is of a deep yellow colour, and is anisotropic, a circumstance probably due to strain from the interposition of other minerals.

CORRESPONDENCE.

NORWEGIAN "RHOMBEN-PORPHYR" FROM THE CROMER BOULDER-DRIFT.

Sir,—In 1884 I collected some erratics from the cliff-sections near East Runton, amongst which was a specimen which proves to be exactly similar to the well-known "Rhomben-Porphyr" of Southern Norway and elsewhere. It will be interesting, perhaps, to put on record the occurrence of this uncommon and local rock. A small piece of this specimen has been sent to the Mineral Department, British Museum (Natural History).

540, King's Road, London, S.W. Chas. D. Sherborne.

THE GLACIAL DEPOSITS OF SUDBURY.

Sir,—As one of those who believe that sea-ice was the main agent in the formation of the East Anglian Drifts, allow me to enter a protest against the conclusions drawn by Mr. J. E. Marr in his paper on the Sudbury sections in the June Number of this Magazine.

He entirely omits to consider the action of coast-ice on a sinking shore, though he must be well aware that this agency has been prominently referred to as concerned in the formation of Boulder-clay.

He asks the question, "Why are not the incoherent Tertiary beds, on which the contorted Glacial deposits rest, themselves disturbed?" and he thinks that this fact is incapable of explanation except by the theory which invokes the passage of land-ice over the East of England. I perfectly agree with him on the point that the incoherent Tertiary beds could only escape contortion by being frozen hard so as to behave like the harder rocks of other districts; but is it, I would ask, only on an actual land surface that such sands could be frozen into a solid mass? I am writing in the country away from books of reference, but think I am correct in saying that the sand on the shores of Siberia is frozen into a perfectly hard and solid mass for some distance below the water, and I think the fact is mentioned in Nordenskiöld's "Voyage of the Vega."

Mr. Marr dismisses the agency of icebergs because he thinks the deposits could not be frozen "over large areas at the bottom of the muddy sea in which the icebergs were drifted;" this is probably true of those parts of such seas in which large and massive icebergs

would ground, but it is not true of the shallower parts near the shore on which the coast-ice acts and on to which floe-ice and pack-ice is often driven with immense force,—agencies which seem to be quite as capable of carrying with them the masses of partially frozen materials and of pushing them over a floor of solid frozen sand as Land- or Glacier-ice could be.

Mr. Marr refers to a recently-described case where a glacier *traversing a narrow valley* seems to have overfolded certain deposits of stratified sand and clay; thus comparing what may happen in a narrow valley with the phenomena of a district of which he himself says "not only do the contortions occur in the drifts which occupy the valley bottoms, but they are also found in the accumulations which lie on the summits of ridges." Are we to suppose that so able a geologist as Mr. Marr thinks an ice-sheet over-riding a ridge will act in the same way as a glacier pushing itself through a narrow valley?

The sections round Sudbury are exceedingly interesting, and Mr. Marr deserves our thanks for calling further attention to them and for recording new aspects of the changing pit-faces, but in his charge to the jury he has not put all the possible alternatives, and consequently his summing-up is biassed in favour of one explanation.

June 6, 1887. A. J. Jukes-Browne.

THE CAUSES OF GLACIATION.

Sir,—I ask leave for a few remarks on the question of the causes of glaciation, as there are some points connected with it on which I think sufficient stress has not hitherto been laid.

The total amount of direct solar heat received at any place is admittedly nearly constant whatever be the eccentricity of the earth's orbit. The amount indirectly received through the medium of air-currents, clouds, and ocean-currents may vary; but if the variations of this indirect heat are ascribed to the raising or lowering of the temperature, the causes of this raising or lowering must be sought for in the distribution of the direct heat. We come, therefore, to the question, What distribution of direct heat over the various seasons (the total amount being unaltered) is most favourable to glaciation?

In the first place, then, it seems clear that the Glacial period could not have been produced by the freezing of water *in situ*. A snow-cap or ice-cap reaching an elevation of hundreds or thousands of feet over the sea-level could only have resulted from falls of snow. The former question is therefore resolved into the following, What distribution of direct heat is best calculated to increase the annual snow-fall?

In answering this question, two principles must be borne in mind. First, that snow will not fall, or at least will not lie, if the temperature is much above freezing-point. In such cases either rain would take the place of snow, or else the snow would melt at once. Second, that very little snow falls when the temperature is very low. Great cold preserves the snow that has fallen, but it seems necessary for a

heavy fall that the temperature should not be much below freezing-point.

I now distinguish three cases.

1st. Where the mean temperature is above freezing-point. Here, if we could distribute equally throughout the year, no snow would fall. Unequal distribution might, however, produce a considerable snow-fall, though not a permanent snow-cap. In mountainous districts extensive glaciers might be produced in this way.

2nd. Where the mean temperature is below, but not much below, freezing-point. Here an equal distribution of heat throughout the year is most favourable to the formation of a snow-cap. Snow would fall at all seasons of the year, and the melting-point being rarely, if ever, attained, the snow-cap would continue to accumulate.

3rd. Where the temperature is much below freezing-point. Here an unequal distribution of heat is most favourable to glaciation, because we must bring the temperature nearly up to freezing-point at one season of the year in order to obtain the heavy falls of snow which are required to form a snow-cap or ice-cap of considerable thickness.

If these principles are correct, they lead to the following results. A high eccentricity of the earth's orbit when the earth is in aphelion at mid-winter is favourable to glaciation in two regions of the Northern Hemisphere, one immediately round the pole and the other much further south (where, however, the result would be rather extensive detached glaciers than general glaciation). But between these two regions there is an intervening one in which the conditions for glaciation would be unfavourable, the snow-fall being less than if the distribution of heat was equable, while a good deal of this lessened snow-fall would be melted by the increased quantity of heat received during the summer. If the earth was in perihelion at mid-winter, this state of things would be reversed. The polar snow-cap would be diminished, but there would be more glaciation in the southern portion of the Arctic region and the northern portion of the Temperate Zone. As far south as Switzerland, however, the glaciation might perhaps again diminish.

In confirmation of these views, I may add that I do not see how the snow-fall could be increased over the entire region from, say, the fiftieth degree of North Latitude to the Pole at the same time. For high eccentricity would not, I apprehend, increase the difference of temperatures between the Equatorial and Polar Regions. It would produce a summer and winter at the Equator—the former when the earth was in perihelion and the latter when the earth was in aphelion; but when the Equatorial and Polar summers and winters synchronized, the contrast of temperatures would not be greater than at present. During the long cold northern winter, on which Dr. Croll lays so much stress, there would also be winter at the Equator, and if we regard the Equatorial region as the generator of vapour or steam and the Polar region as the condenser, the apparatus as a whole would not be more powerful but less powerful than before. There would be no increase in the quantity of aqueous vapour available for the

production of falls of snow in the higher northern latitudes, and, therefore, an increased snow-fall in one portion of these latitudes must be compensated by diminished snow-fall in another portion.

I have omitted to notice the effects which might be produced when the snow-caps thus formed were set in motion. Moving masses of ice or snow might considerably alter the general phenomena of glaciation. If we take the most southerly portion of our hemisphere in which permanent glaciation is possible, the snow-cap would form most readily if the irruption of northern ice commenced about the same period when the conditions for local glaciation were becoming favourable. These latter conditions would, I apprehend, be most favourable when the earth was in aphelion at midsummer; but the Polar Pack would not attain its full dimensions until some time after the mid-winter aphelion, and in its slow southward motion it might not begin to overrun the northern portion of the Temperate Zone until a still later period. The invasion of Polar ice might nearly coincide with the commencement of the local glaciation produced by very different causes, and a Glacial period would result.

13, Belvidere Place, Dublin, W. H. S. Monck.
May 7th, 1887.

OBITUARY.

EDWARD TOWNLEY HARDMAN, F.C.S., F.R.G.S.I., ETC.

Born 6th April, 1845; Died 30th April, 1887.

GEOLOGICAL science has suffered a serious loss in the early death, from typhoid fever, of Mr. Hardman, of the Irish branch of the Geological Survey of the United Kingdom.

Descended from an old and respected Drogheda family, Mr. Hardman received his early education at that town. Having by his ability won a Government Exhibition and entered the Royal College of Science, Dublin, in 1867, he obtained a diploma in mining, etc., as well as numerous prizes, and in 1870, he was appointed to the staff of the Geological Survey of Ireland. In 1871 he was elected a Fellow of the Geological Society of Ireland, and in 1874 of the Chemical Society of London.

He examined, and prepared a Memoir upon, the Geology of the Coal-fields of Kilkenny and Tyrone, and prepared a list of papers on the Geology of the North of Ireland. Mr. Hardman was also an active and earnest antiquary, and communicated several papers to the Royal Irish Academy.

In 1883 he was selected by the Colonial Office to examine and report upon the geology and mineral resources of the Kimberley district of the colony of West Australia. Here he was attached to a local surveying expedition, under the direction of the Hon. J. Forrest, C.M.G., Crown Surveyor General to the Colony, and set out for the North-East Territory. Having a camera, he was enabled to photograph numerous points of interest, and also to make sketches of characteristic geological sections. The most important practical

result of his investigations was the discovery of an extensive gold-field in the vicinity of the Napier Range in the Kimberley district, where by actual experiments he was able to attest the presence of auriferous deposits at various points.

There is no doubt that Mr. Hardman's work was performed in such an efficient and satisfactory manner that he would have been at once appointed as geologist to the Colony, but for the difficulties raised by the Legislative Council on the subject of expenditure. His engagement having terminated, he returned home in October, 1885, bearing however the assurance that he would certainly be appointed if the post was created.

Last year he was called upon to assist in the arrangement of the rocks, fossils, and minerals sent by West Australia for the Colonial and Indian Exhibition in London.

He had returned to his duties on the Irish Survey, and in March last he inspected a district in the Wicklow Mountains and adjacent country, with the view to compiling a second Survey Memoir thereon; his constitution no doubt suffered owing to the inclemency of the weather and frequent exposure to swnostorms and rain amongst the hills, so that when attacked by fever he was too reduced in health to withstand its effects, and he passed away after only a few days' illness, leaving a widow and two young children quite unprovided to face the struggle for existence deprived of a father's protection and support.

It is all the more sad to think that had he lived the long-desired post of geologist to West Australia would have been offered to Mr. Hardman, the financial difficulties in the way of his appointment having been removed just before he died.

A considerable reward had been offered by the Government for the discovery of gold in the colony, and Mr. Hardman was at the time of his death a claimant for the prize. It is earnestly to be hoped that the Legislative Council will be pleased to award at least a part of such premium to the widow of the man who discovered the Kimberley Gold-field.

The following is a list of the papers of which Mr. Hardman is the author:—

1. On the Analysis of Trachyte Porphyry from Tardree Quarry near Antrim. Roy. Geol. Soc. Ireland, May 10, 1871.
2. On the Analysis of a Limestone compared with that of the same rock where it is in close proximity to a Doleritic Dyke. R.G.S.I., June 14, 1871.
3. On the Occurrence of Gypsum in Keuper Marls near Coagh, Co. Tyrone. R G S.I., June 12, 1872.
4. On the Recent state of Coal Mining in the County of Tyrone. Roy. Dub. Soc., Nov. 18, 1872.
5. List of Geological Papers on North of Ireland. Mems. G. Sur. I., 1872.
6. On the Occurrence of Silicious Nodular Brown Hæmatite (Gothite) in the Carboniferous Limestone beds near Cookstown, Co. Tyrone. R.G.S.I., May 14, 1873.
7. On Analysis of White Chalk from the Co. Tyrone; with Notes on the occurrence of Lime therein. R.G.S.I., June 11, 1873.
8. Notes on a Small Raised Beach at Tramore Bay, Co. Waterford, showing traces of severe oscillatory movements during the recent period. R.G.S.I., Dec. 10, 1873.

9. On the Substitution of Zinc for Magnesium in Minerals. Roy. Irish Acad. vol. i. 1870, p. 533; Geol. Mag., May, 1874.
10. Further Researches on the supposed Substitution of Zinc for Magnesium in Minerals. R.I.A., vol. iii. p. 146.
11. On Bones discovered in a Cave of Dunmore, Co. Kilkenny. Proc.R.I.A., 1870-1879, p. 354.
12. On Two new Deposits of Human and other Bones discovered in the Cave of Dunmore, Co. Kilkenny. P.R.I.A., February 22, 1875.
13. On the Age and Mode of Formation of Lough Neagh, Ireland; with Notes on the Physical Geography and Geology of the surrounding country. R.G.S.I., January 13, 1875.
14. On the Origin of Anthracite, with suggestions as to the possible Correlation in time and manner of Production of the Anthracite of Southern Ireland, Wales, Devonshire, and France. R.G.S.I., 1875.
15. On the Sub-Glacial Theory of Gravels. Geol. Mag., April, 1875.
16. Analysis of Coals and Ironstones from the Dungannon Coal-fields, Co. Tyrone. R.I.Acad., February 28, 1876.
17. A Contribution to the History of Dolomite (with plates). R.I.Acad. (xli. and xlii.) vol. ii. p. 705.
18. The Dolomites of the Carboniferous Limestones of Ireland. R.I.A., May 8, 1876.
19. Fossiliferous Pliocene Clays. Geol. Mag. Dec. II. Vol. III. p. 556, 1876.
20. On a Triple System of Post-Miocene Faults in the Basaltic Region around Lough Neagh. R.G.S.I., April 11, 1877.
21. Memoir on Tyrone Coal-field. Mems. G.S.I., 1877.
22. Chemical Notes in Connection with Prof. Hull's paper on the Nature and Origin of the Beds of Chert in the Upper Carboniferous Limestone of Ireland. R.G.S.I., May 9, 1877.
23. On the Barytes Mines near Bantry. R.G.S.I., January 21, 1878.
24. On Hullite: a hitherto undescribed mineral: a hydrous Silicate of peculiar composition from Carnmoney Hill, Co. Antrim, with analysis. R.I.Acad., June 24, 1878.
25. Preliminary Report on Soundings in Lough Gill, Co. Sligo. R.I.A., vol. iii. p. 473.
26. Memoir on the Kilkenny Coal-field. Mems. G.S.I., 1881.
27. First Report to Government on the Geology of the Kimberley District, West Australia. 1884.
28. Second Report to Government on the Geology of the Kimberley District, West Australia. 1885.
29. Notes on a Collection of Flint Implements and other Weapons, etc., from Tropical Western Australia. R.I.A. (in course of publication). Read 22 February, 1886.
30. Catalogue of the Geological Survey (Ireland) Library (for private official use). 1886.
31. Notes on some Habits and Customs of the Natives of Kimberley, West Australia. R.I.A. (in course of publication). Read 10 January, 1887.
32. Memoir on the Geology of the Country in Sheets 148-49 Geol. Surv. Ireland. Mems. G.S.I. (in the press). 1887.
33. Note on Professor Hull's paper with reference to Dr. Hinde's paper on Beds of Sponge Remains; Greensand. Royal Society, Lond, April 28, 1887.

A. B. W.

It is with deep and sincere regret that we record the death, on the 5th June, of our friend and fellow-worker in geology, Arthur Champernowne, Esq., M.A., F.G.S., of Dartington Hall, Totnes, S. Devon, aged 48 years. We hope to publish a notice of his life and work in our next Number.—Edit. Geol. Mag.